PROJECT REPORT

06-73

VEGETATION AND OTHER PARAMETERS

IN

THE BREVARD COUNTY BAR-BUILT ESTUARIES

1978

BREVARD COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL ENGINEERING

CHERIE DOWN

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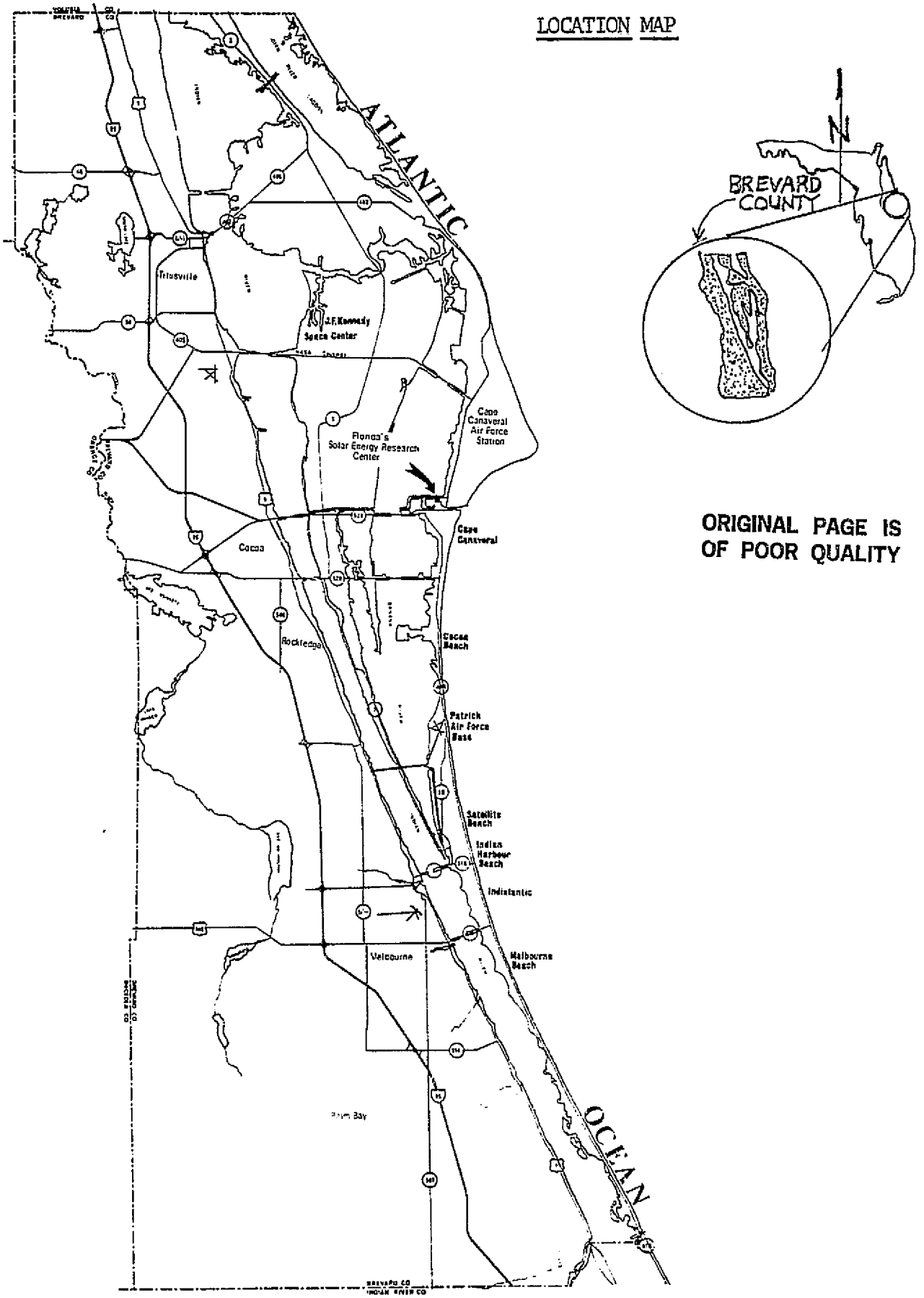
LOCATION MAP



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ABSTRACT

This project was conducted through a cooperative effort between the National Aeronautics and Space Administration and the Brevard County Health Department.

The project consisted of obtaining several sets of aerial imagery using various techniques, testing the imagery by using several data analyses methods, and groundtruth and biological testing.

The project provided highly positive proof that low altitude aerial photography using specific techniques can effectively delineate sea-grass beds, oyster beds, and other underwater features.

This study, the first of its kind for this area, made it possible to map the above features. The maps represent an approximate total 45,000 acres of grassbeds; 2,500 acres of oyster beds; and 4,200 acres of dredged canals. This data represents selected sites, only, and is not a total portrayal of Brevard County waters.

Areas chosen for this study were selected on the basis of their water quality. All four areas (2, 5, 6, 7) are designated as Aquatic Preserves. Two of the areas (5, 7) are also designated as Class II shellfish harvesting waters.

The above sites have the highest quality of water in Brevard County,

and are among the most highly recognized biologically productive waters of the State of Florida.

This study also provides specific interpretive techniques to be used to assess similar features in other areas.

The groundtruth portion of this project, an on-going program of the Brevard County Engineering & Pollution Control Section, began in 1970. The aerial imagery was obtained in 1974 and 1975. The biological data assessment for this report includes data through the year 1975, to coincide with the aerial imagery data acquisition.

The biological testing has continued beyond the time and preparation of this report and will be evaluated to compare with data obtained within this project.

INTRODUCTION

Many people view the Indian and Banana Rivers as water columns to use for boating, water skiing and fishing. The rather substantial commercial fishing industry views it as a medium for crabbing, oystering and net fishing. The land developer regards it as a scenic asset for waterfront development and thus a source of increased income. The biologist views it as an estuarine ecosystem supportive of a vast variety of life and probably one of the biggest natural and commercial assets of Brevard County.

The present study focuses on the plant life, called Primary Production, dealing with macro and micro algae. It is well to point out that most of Brevard County estuarine river bottoms are covered with seagrass beds. Several functions of these grass beds are as follows: 1) Marine vegetation serves to stabilize the river bottoms and helps prevent erosion by wave action; 2) Seaweeds provide food and shelter for the many inshore and offshore fish using the estuaries for spawning and many other stages of their life cycles. Approximately 80 per cent of all available offshore fish depend on these shallows covered by seagrasses to spawn and grow; 3) Grass beds provide home, food and shelter for crabs, shrimp and shellfish; 4) Grass beds have invaluable capabilities in naturally removing nutrients from the water systems; 5) Seagrasses also have an important function as oxygen producers and

other chemically important water components.

In 1969, the Brevard County Health Department undertook an estuarine survey study to establish baseline qualitative productivity levels in our county waters. This investigator has been involved in this survey on the primary production level. Analogy behind this survey is simple. It is reasoned that food reaching the water is utilized on an inorganic and an organic level by the plant kingdom. The growth rate, pattern and quantity of these "weeds" will be a useful indication of how much nutrient is being added to the waters and how much food can these weeds produce for higher forms of life, such as fishes.

The inshore and offshore fishing industry depends on a thin ribbon of shallows surrounding the State of Florida. The seagrasses and seaweeds are the primary sources of energy conversion, food, and shelter for our fishing industries. If we delineate and evaluate these grassbeds, then we are better able to protect and maintain their integrity.

The cooperative effort of NASA and Brevard County hoped to reach the following goals:

1) To develop remote sensing and data analysis techniques to determine the quality and the quantity of various estuarine parameters (algae, etc.) that have an effect on the production of estuarine waters.

2) To produce maps showing the various estuarine parameters.

3) To determine if aerial photographic survey methods prove to be time saving and are accurate in the assessment of underwater biological features in any Florida estuary.

4) To develop specific interpretive techniques to be used on a universal scale to assess similar underwater areas.

GENERAL CONSIDERATIONS

Brevard County is located on the east coast of the State of Florida approximately at the mid point of the Florida peninsula. The county is approximately 70 miles (113 Kilometers) long and borders on the Atlantic Ocean. The neighboring counties are Orange and Osceola on the west; Volusia on the north; and Indian River County on the south.

Brevard County is approximately 20 (32 Km) miles wide and consists of 1298 square miles (3362 square Km). The major water bodies are the St. Johns, the Indian and Banana Rivers.

Lying west of the coastal ridge, the St. Johns River has its head waters in Lake Blue Cypress. This fresh water river runs north and eventually to the ocean in the Jacksonville area. Subject to periodic drought and flooding, the St. Johns River provides extensive fishing and wildlife resources. Lake Washington, the primary source of water supply for the City of Melbourne, is part of the St. Johns chain of lakes and is a vital consideration of Brevard County. This need initiates a perpetual concern over the quality of the waters of the St. Johns River.

The Indian and Banana River complex lies east of the coastal ridge and is separated from the ocean by a series of barrier islands. The Indian and Banana, including the Mosquito Lagoon estuaries, are shallow, non-tidal, wind-tide mixed bodies of water ranging from less than one to

approximately four meters in depth. The bottom of these rivers consists of sandy grassbeds and algae. The depressions often contain fine grain sediments containing anaerobic material and often supporting two species of seaweeds. These depressions include the canals and many portions of the intracoastal waterway which runs through the portion of Mosquito Lagoon in Brevard County, continues west and through the Haulover Canal in the Indian River and extends south and to Indian River County.

The Indian and Banana Rivers, including the Mosquito Lagoon and the Sykes Creek and Newfound Harbor area, constitutes 257 (666 square Km) square miles of the total Brevard County area. One fifth of Brevard County consists of the above salt water system, well known as highly productive sources of commercial and recreational interests in the State of Florida, and is in dire need of documentation.

The major nutrient input to the salt water rivers include treated effluent discharged by the various sewage treatment plants, and storm water runoff serving as a carrier of various nutrients and chemicals. The exact effect of these input sources is not well known. There is, however, a well recognized correlation between nutrient input and algae growth. A delicate balance, therefore, exists between input and production. The solution to this easily recognized problem is the goal of many present water quality studies.

CLIMATE

Brevard County climate has been described as mild and subtropical. The yearly average temperature is 22°C (71.6°F). The 1965 to 1975 range was a low of 2°C (35.6°F) and high of 36°C (96.8°F) with the average winter temperature of 32°C (89.6°F).

The rainy season begins in May and extends to October, bringing an average rainfall of 125 cm per season.

The area mean wind velocities are 8 and 12 knots with summer east to southeast and winter, northwest to northeast prevailing winds. The climate is subtropical and humid.

The major sources of overland fresh water runoff to the lagoonal estuarine system in Titusville include Turnbull Hammock, and to some degree, Banana Creek; and in the Melbourne area, Eau Gallie River, Crane Creek, Turkey Creek and the Sebastian River.

Direct rainfall and surface runoff are two other sources of fresh water input, with a counter balance of water loss through evaporation and osmosis due to the differential water levels between the river and the Atlantic Ocean. Subsurface springs also constitute a source of fresh water input.

The two ocean connections are Sebastian Inlet in the Indian River and a limited connection through the Cape Canaveral locks in the Banana River.

The area water salinities average in the low 20 parts per thousand, excluding droughts. Brevard County Health Department data indicate average lows to be as low as 19.8 ppt and average highs of 28.9 ppt. Higher salinities prevail in the north Indian River and Mosquito Lagoon area, as well as to areas approximately a mile north of the Sebastian Inlet. These areas exhibit higher salinities than the above figures. South Mosquito Lagoon and associated salt pools exhibit salinities often averaging in the 40 parts per thousand, four parts per thousand higher than the neighboring Atlantic Ocean. The above is probably due to evaporation.

The mouth of each fresh water river reaching the salt water systems exhibits lower salinities, a feature which disappears within a small mixing zone as it reaches the river.

The area surface water temperatures average from a winter temperature of 23.9°C (75°F) to summer temperature of 30.0°C (86°F). This data is based on a six year estuarine study and does not include all time high and low values.

STATE OF FLORIDA WATER CLASSIFICATION

AND

SPECIAL DESIGNATION MAPS

BREVARD COUNTY, FLORIDA

The Florida Department of Environmental Regulation has categorized the waters of the State of Florida into various water use classifications.

Brevard County waters range from Class 1 to Class III, as depicted on the following maps. Water classifications are as follows:

Class 1 - Public water supply

Class 2 - Shellfish propagation and harvesting (P. 13)

Class 3 - Recreation - Propagation and management of fish and wildlife (P. 12)

The Trustees of the Internal Improvement Trust Fund have designated certain areas of high aesthetic or biological productivity as Aquatic Preserves. Brevard County has three such areas designated as Aquatic Preserves of the high biological productivity type. These areas are also shown on the following maps. (P. 14).

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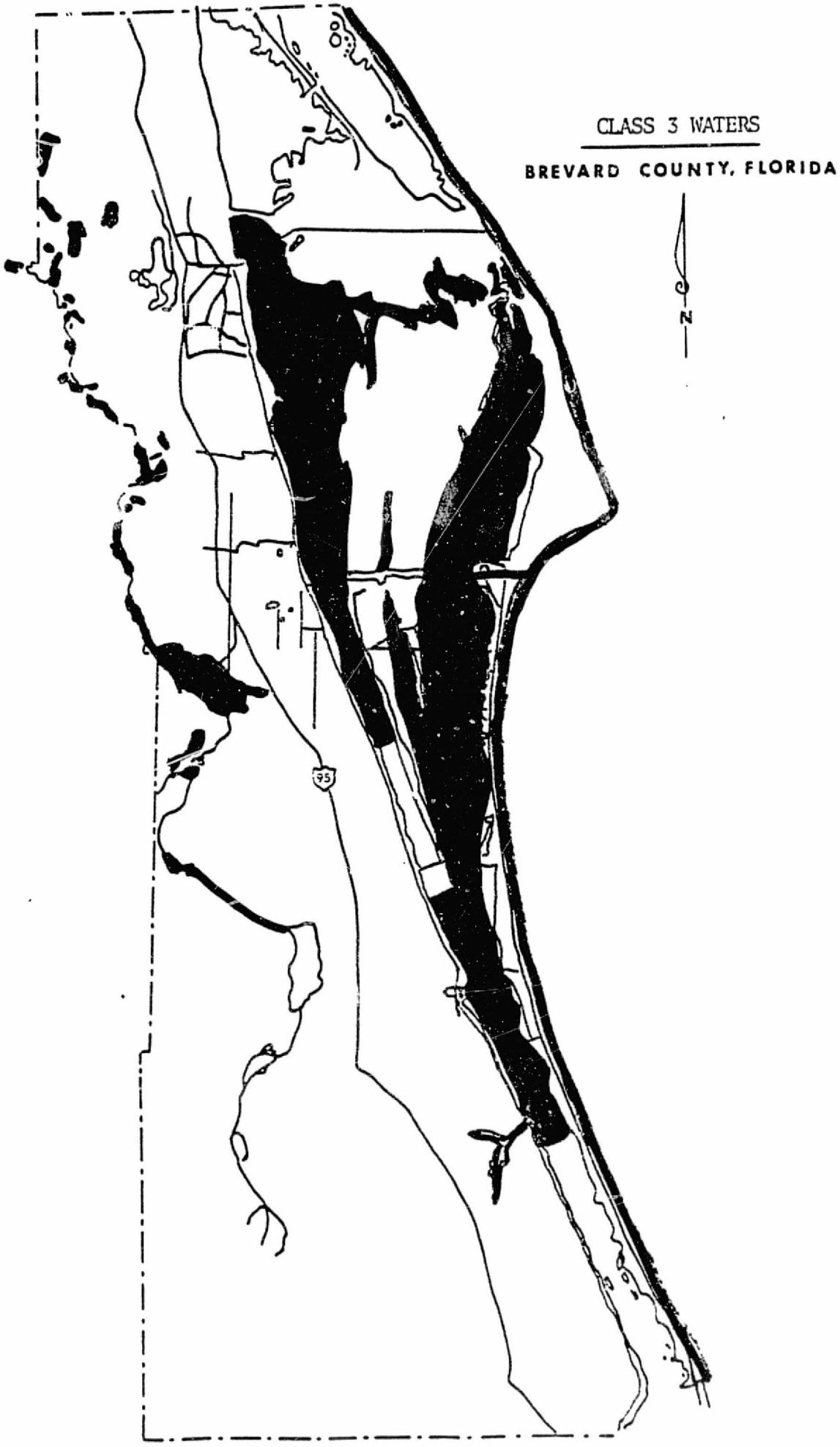
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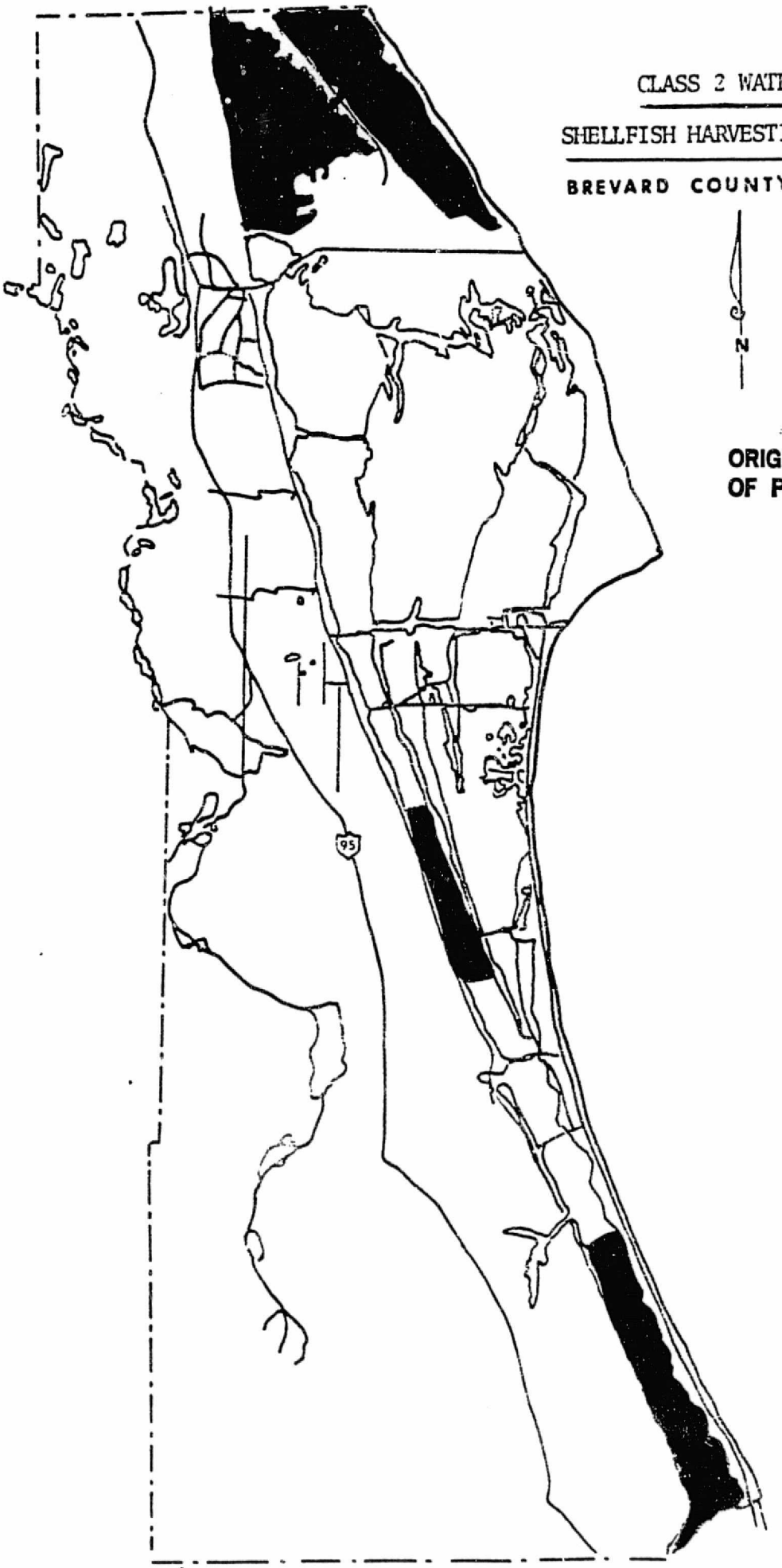

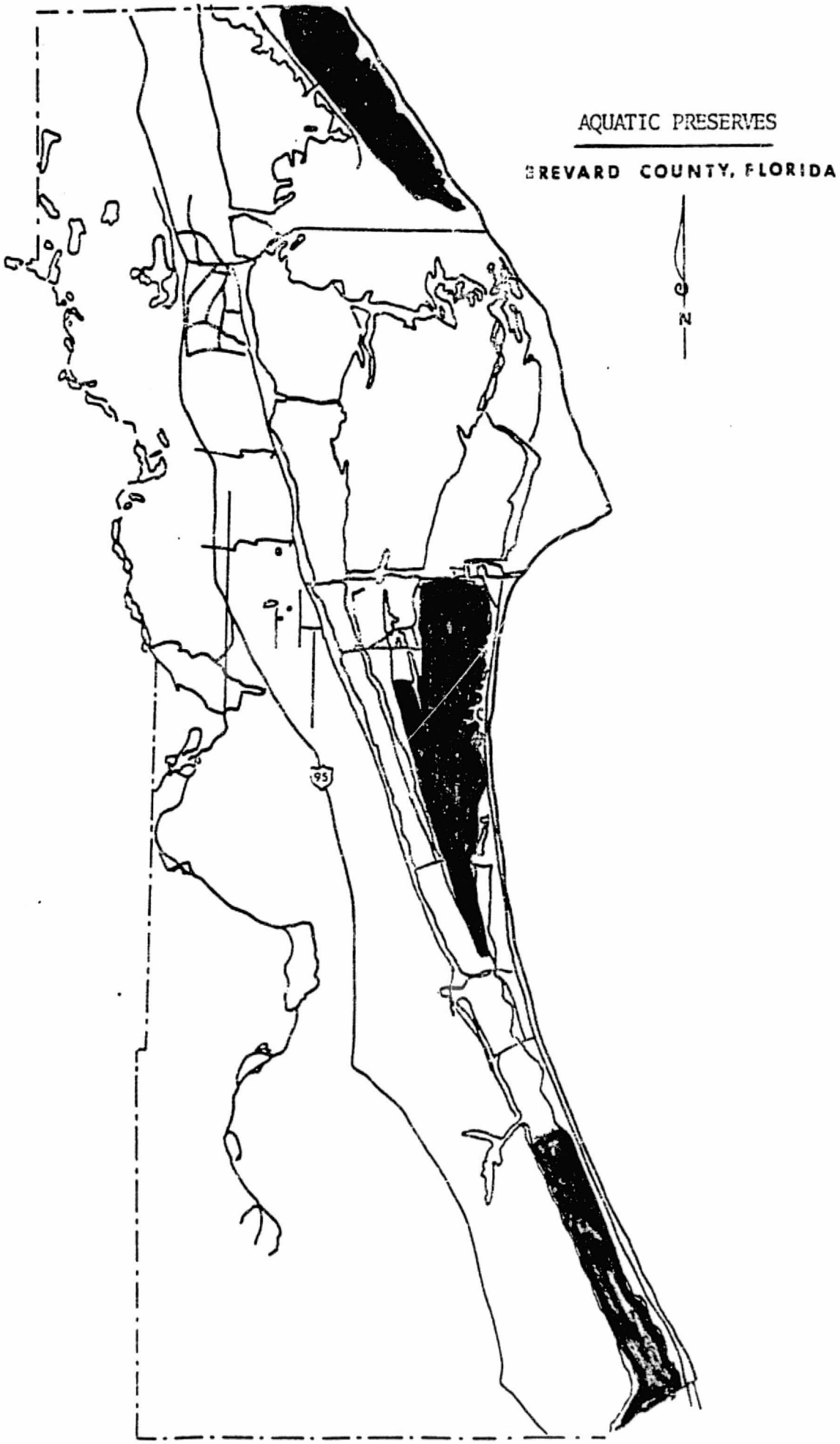
AQUATIC PRESERVES
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B. COLLECTED DATA

METHODS AND MATERIALS

a. Imagery

The aerial imagery was obtained from the NASA 6 aircraft. The film used was a Kodak Infra-Red Aerial-graphic film, Type 2443. Since this film is blue-sensitive, filters were used for red, green and infra-red expression only. A Wratten 12 or 15 filter was used. The imagery scale is 1- to 12,000. Some of the flights were flown at 6,000 feet (1.829 Km) with a 6-inch (15.25 cm) lens, or at 12,000 feet (3.658 Km) with a 12-inch lens (30.48 cm).

The aircraft speed varied between 125- to 150 knots (231 to 277 Km/Hour). Flights were planned for days with no more than 15 per cent cloud cover and with winds less than 10-miles (16.09 Km/Hour) per hour. The summer season sun angle requirements were between 30- to 50- degrees, with a much wider allowance in the winter season. The final products processed at NASA are in 23 by 23 cm transparencies. The two cameras used were the KA-2 and Zeiss. The aircraft used, NASA-6, is a twin engine Beech-craft with the cameras mounted on the bottom.

b. Biological Sampling Techniques

Brevard County Health Department owns two boats, both of which have been used throughout the course of this project. The data results throughout the study area are discussed within each section

A 10 meter square area was used for each seaweed collection, where the study is confined to the qualitative aspects of the seaweeds.

The seagrass samples were obtained by using an Ekman dredge, as well as a devised "plug" method. The "plug" was able to provide a 10 cm sediment depth and allow for root system measurements as well as blade counts. Light diving gear was used for some of the collections. A Peterson dredge was used in areas involving canals and the inland waterway channel sampling.

All chemistries were conducted at the Brevard County laboratory according to The Standard Methods For Water and Wastewater Analysis[1]. Chlorophyll tests were conducted by the Strickland & Parsons[2] method. The Ekman dredge used for bottom sampling was calibrated to compare with a devised plug method for sampling in the shallower areas.

All phytoplankton, chlorophyll and chemicals were cooled on the spot, kept in the dark, and processed unpreserved. All seaweeds, whenever not processed, fresh, were preserved in 5 per cent seawater buffered formalin

b. Biological Sampling Techniques

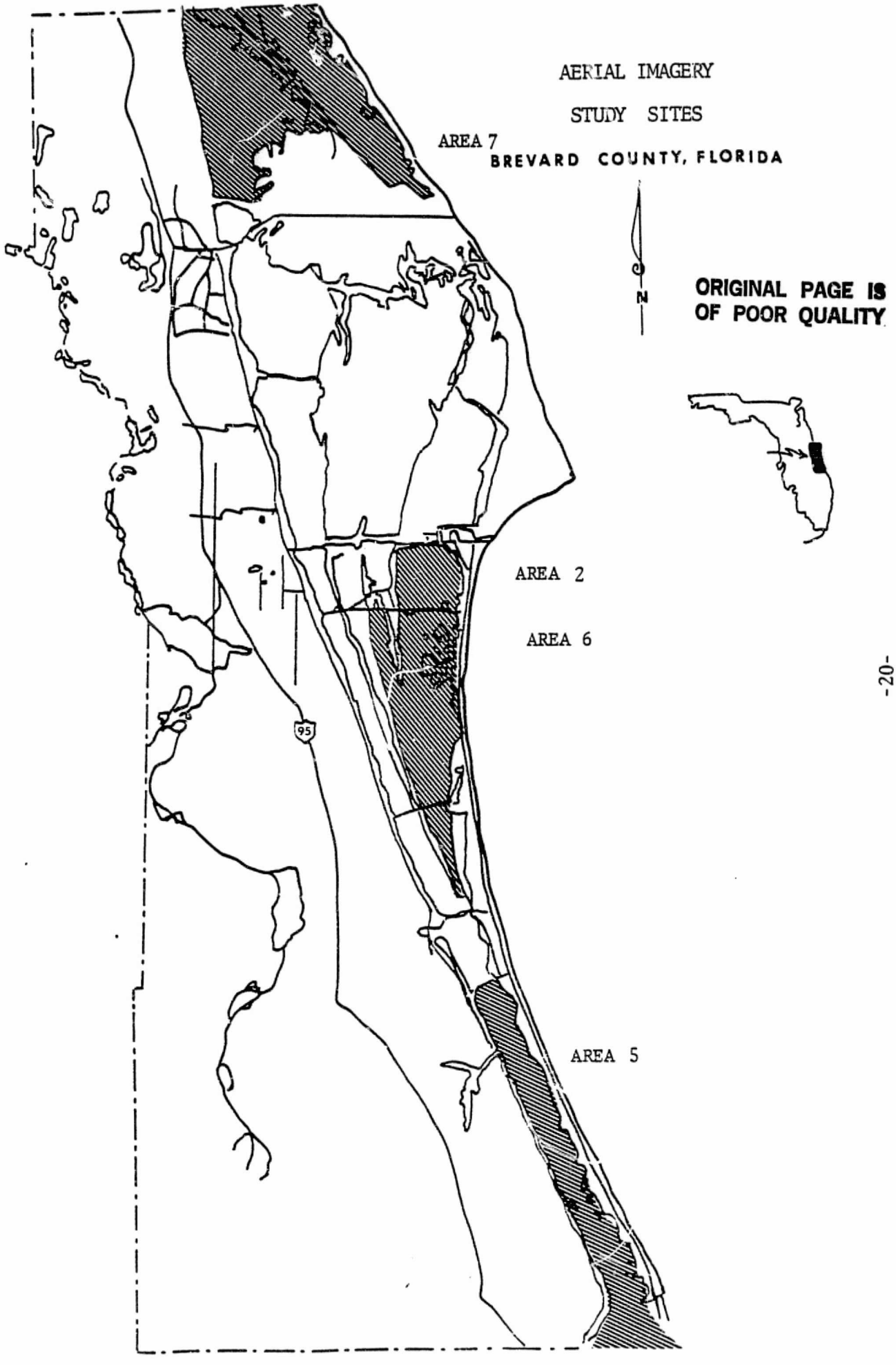
[1]Standard Methods For The Examination of Water and Wastewater. American Public Health Association, Inc., New York. 1965.

[2]A Practical Handbook of Seawater Analysis. J. D. H. Strickland, and T. R. Parsons. Fisheries Research Board of Canada. Ottawa, Canada. 1968.

for identification. Seagrasses were measured and enumerated, blotted dry and weighed.

A sample of all seaweed species was preserved and pressed for future reference. Some microphotography was used for phytoplankton documentation where preservation was not possible.

C. DATA ANALYSES



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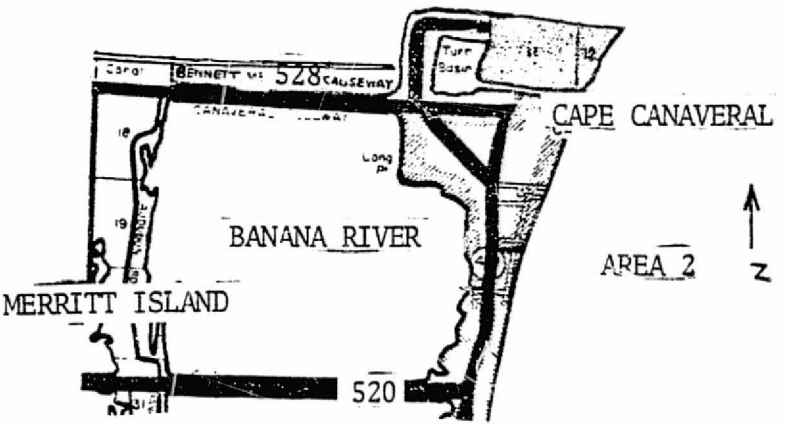
AREA 2



AREA 2

General Description

Area 2 is located in the Banana River between the 520 and the 528 Causeways. The eastern shoreline of this area adjoins the City of Cape Canaveral. The shoreline consists of a series of canals with single family homes and a central portion with a seminatural shoreline, consisting of single and multifamily zoning. Some of the waterfront portion of this area is undeveloped.

The City of Cape Canaveral sewage treatment plant is located on the northeast shoreline of the area. The present plant design capacity is listed at 850,000 gallons per day, and the plant is currently operating at 62 percent capacity. The secondary treated effluent reaches the Banana River.

The northern limits of this study area is the 528 Causeway and bridge system. Built in 1957, this system rechanneled and limited the normal area water circulation, confining it to within and between the two bridge span areas. The modification to the natural Banana River system includes extensive filled areas at both the east and the west portions of this study area and a resultant constricted circulation. This constriction has created large shallow corners where water movement is further impeded and circulation pattern indicates stagnant conditions.

General Description (Continued)

The Canaveral locks are approximately one-fifth of a mile north of the 528 Causeway. The salinity tests conducted are, so far, inconclusive of the effect of the locks on the Area 2 waters.

A county park is located in the corner of the north and the west boundaries of Area 2. Kelly Park consists of a filled area used for picnicing and a boat launch. Less than half of the western shoreline has, so far, remained natural, with the balance consisting of many dead end canals with single family residences.

Brevard County Utilities Central Avenue treatment plant serving the North Banana River area with a 300,000 gallons per day capacity, has a secondary treatment pipeline placing effluent directly into the Banana River at the end of Central Avenue, approximately in the middle of the Area 2 western shoreline. This plant is currently operating at 83 per cent capacity. Sewage treatment plants are a major source of nutrient input into the waters of Banana River Area 2.

The Milford Point Road peninsula, approximately a mile long, constitutes the south portion of the above shoreline.

The 520 Causeway is the southern boundary of this section. The Banana River bridge with a system of the usual two relief bridges forms this man-made shoreline. The City of Cocoa water storage tanks and the Cape

General Description (Continued)

Canaveral Hospital are the predominant features located on this filled area causeway. Most of the land water interface in this area consists of invaded natural vegetation including various mangroves.

There are approximately 15 man-made dead end canals connected to Area 2 waters. These canals are approximately 15 to 45 meters wide and 1 to 3 meters deep. A large dredged area adjacent to Cape Canaveral Hospital is a prominent feature of the underwater imagery. Residential canals and dredged areas usually cause elimination of grassbeds.

There is a channel approximately in the center of Area 2. This north-south channel is approximately 4 meters deep and is between the 528 and the 520 bridge sections of the two causeways.

A north to south sandbar extends the entire length of this area with seasonally fluctuating water depths of less than 0.3 meters. The bar is heavily covered with seagrasses and seaweeds, one of the most densely vegetated areas in this entire system.

Historical Data

The Trustees of the Florida Internal Trust Fund designated this area as an aquatic preserve. This designation was based on a state study identifying and delineating shallow areas of high value for spawning and the propagation of fish and other aquatic life.

AREA 2

RESULTS - GROUNDTRUTH

Where not developed, the shoreline is bordered with white and black mangroves, some cord grass (Spartina bakeri) and other vegetation. The descent from the west shoreline is quite gradual. From the shoreline up to approximately 5.5 yards (5 meters) out in the river, the depths average about 30 to 45 centimeters. This shallow zone is entirely free of grasses. This area receives the initial rain runoff impact and has a higher range of salinity. Nutrient uptake in this zone is entirely microscopic. The prevalent winds, as well as specific water circulation patterns, help hold water within this zone. This zone is also the recipient of large seaweed deposits which blow ashore to decompose all through parts of fall and winter. The decomposition here is through micro-algae, marine yeasts, molds and fungi, with frequent blooms of Dinoflagellates, such as Gymnodinimum splendens.

Several times a year this shallow zone forms small fresh-water pools which support a growth of duckweed. The bottom here generally consists of fine particulate sand and some silt.

The next depth zone is the Ruppia maritima and Diplanthera wrightii zone, extending out to a water depth of one-half meter to one and one-half meters.

In this section Ruppia maritima borders the shallower, lower salinity areas. Never as dense as the other grasses, usually it appears late in May and disappears in August or September.

RESULTS - GROUNDTRUTH (Continued)

The next predominant grass zone is Diplantera wrightii with Syringodium filiforme extending to the two and one-half meter depth.

The aerials reveal depth features up to 2 meters depending on the seasor. A 4-meter-deep channel forms the deepest part of this study area. The two seaweeds Gracilaria blodgettii and Hypnea cornuta were collected by the dredge from this zone. These seaweeds were heavily covered with tunicates and sponges. A dissolved oxygen sampling at one foot intervals in this area indicated dissolved oxygen levels of 7 ppm at the surface to 4 ppm on the bottom.

Also, four different salinity readings correlated with depth, suggesting vertical layers of water movement.

The channel bottom exhibits typical fine sediments associated with deeper areas and typical of this particular section. The grain size and associated invertebrates are the subjects of the Brevard County Health Department staff biologist, Mr. Ray Grizzle's study.

There is a gradual depth reduction east of the channel leading to a ridge. This shallow ridge runs the entire section in a north-south direction. This zone is also a Diplanthera - Syringodium covered area. The very gradual shallow zone reaching the east shoreline supports a wider Ruppia growth zone.

RESULTS - GROUNDTRUTH (Continued)

A fourth seagrass Halophila engelmannii grows at random regardless of depth.

The area seasonal water chemistry test results do not seem to indicate excessive values in comparison with other Class 3 waters. Salinities range between 24 to 28 parts per thousand. Seasonal chlorophyll *a* ranges from 1.4 to 12.3 mg/m^3 with an average of 5.3 mg/m^3. Summer chlorophyll profiles are somewhat higher than the winter profiles. The pH ranges between 6.5 to 8.1.

The phytoplankton profile is more diverse and plentiful in the winter months. Frequent patches of Dinoflagellate blooms occur in this area.

Seaweeds in this area are somewhat substratum specific. There is no zonation of different types corresponding with the depths. They occur with hold-fast on rocks, shells, tubeworms, seagrasses, and other seaweeds.

The area seaweeds are quite seasonal and exhibit a lush growth in the summer with an almost total drawback in the winter season. The epiphytic algae in this area constitute a large percentage of the total seagrass weights. Predominant species include seasonal greens and reds.

appear in specific patterns.

A thin ribbon of decaying drift algae was apparent on the January imagery and appeared as wavy orange-red lines.

The IMAGE 100 is an image analysis system which performs high level analysis of imagery recorded on magnetic tape such as LANDSAT, multraspectral scanner tapes and on both black and white or color photographic imagery. Major functions include signature extraction training on as many as five channels of data, thematic mapping, optical transformation, interactive signature manipulation, and many other sophisticated computer assisted enhancements.

One of the problems faced in using the above method was that the same signature was produced by IM 100 for grassy areas and deep waters. To remedy the above, density slicing was performed using the micro-densitometer.

The microdensitometer is a precise film density reader/writer with computer enhancement capability. Color or black and white imagery up to 9" x 9" can be scanned down to a 12.5 micron spot size. Film density, digitized into 256 levels, is stored on magnetic tape for

AREA 2

RESULTS - IMAGERY

A roll each of color and color infrared summer season imagery was taken in March of 1974, using the KA-2 camera with a 6" lens. The flight altitude was at 6,000 feet. The winter imagery was taken in late January of 1974 using a Zeiss camera. The film utilized for this flight was Kodak number 2448 for color, and Kodak number 2443 for color IR. The imagery was obtained at an altitude of 6,000 feet.

The seagrass beds were delineated on vegetation maps enclosed in this report. The maps were prepared using the 6-inch square section of each frame in a mosaic fashion. Where the water does not exceed about one meter, the attached vegetation is readily distinguishable from sandy areas.

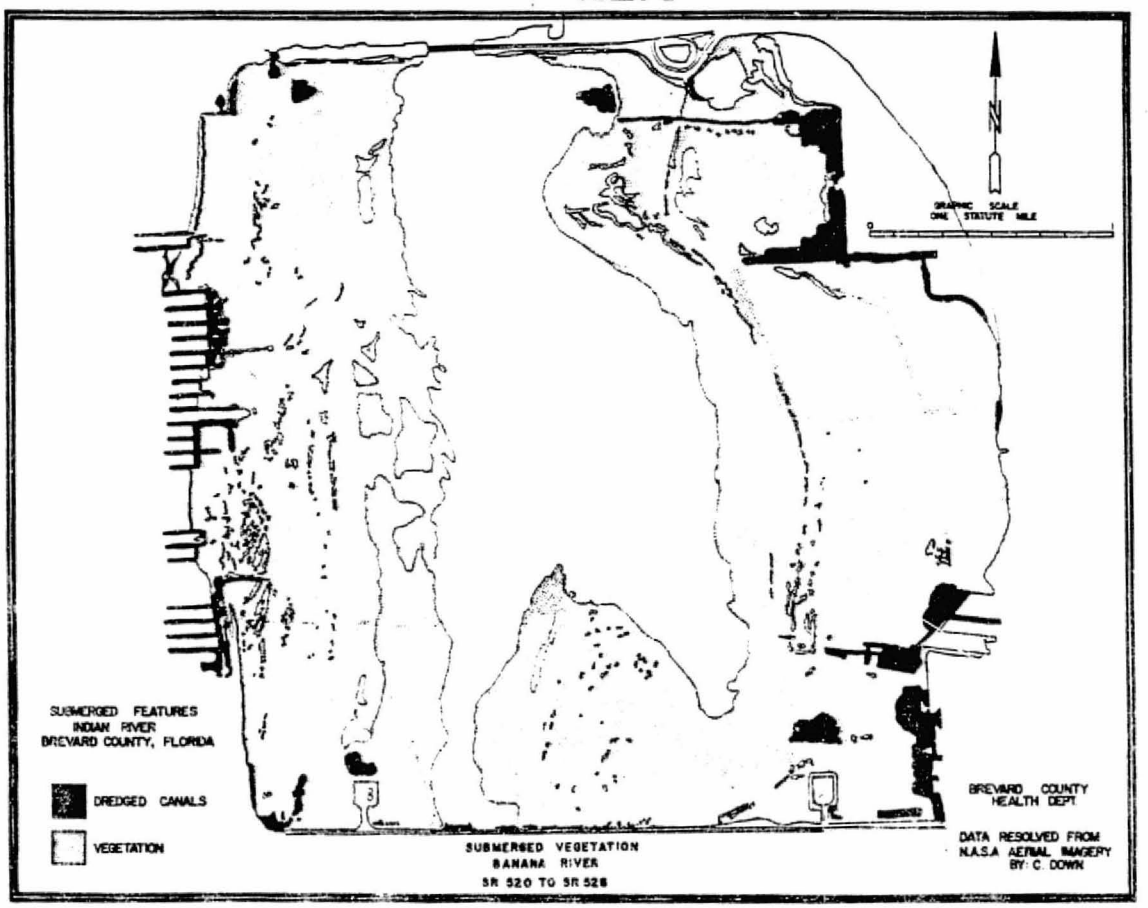
With the present phytoplankton loads in this area, the maximum water penetration capability of the imagery was almost two meters. Beyond that depth, the light penetration was not adequate to delineate grasses from non-grass areas.

The dredged areas such as canals or the area dredged to create fill material for the Cape Canaveral Hospital are easily detectable, appearing as uniform dark areas.

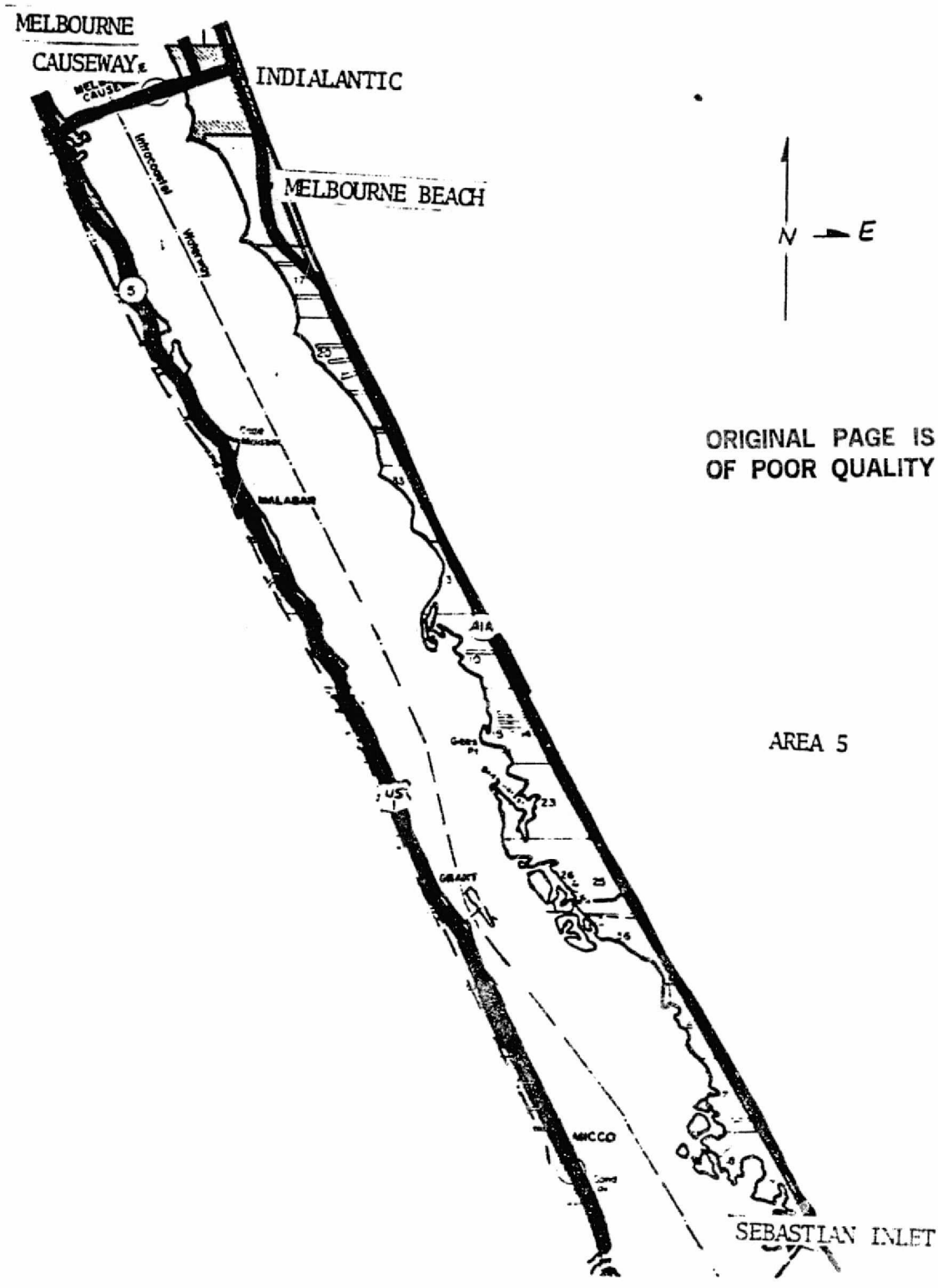
Since seaweeds are substratum specific, they can be detected on the imagery by their hard rock or shell substratum. Such hard bottom areas

use by the IMAGE 100 or for computer transformation. Enhanced data can be displayed real-time on the Digicol CRT or be printed on film. The system computer can density slice, change contrast, enhance edges where gray levels change, enlarge, reduce, or apply algorithms for image enhancement. Using the microdensitometer provided some positive results. The blue band was able to show a separation between the grassy areas and deep water areas found undifferentiated in using the IM 100.

AREA 2



AREA 5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AREA 5

General Description

Area 5, located in the Indian River, consists of an area approximately 18 miles (29 Km) long and two (3 Km) miles wide. The north boundary of Area 5 begins roughly a mile south of Turkey Creek, at the point of Port Malabar. The south county line and Sebastian Inlet are the southern boundary of Area 5.

The south shellfish area (Area 5) is economically the most note-worthy oyster harvesting area of the county. There are approximately 82 oyster leases within this section; a major contributor of a total of 4,087,686 pounds of shellfish harvested in Brevard County waters in 1975.

The eastern shoreline is sandy, shallow, and supports a dense growth of seagrasses. The upland zones consist of sparse development and marsh areas. The shoreline is frequently dotted with red mangrove (Rhizophora mangle) and black mangrove (Avicennia germinans). Modifications to the above marsh sections consist of diking activities for mosquito control purposes. The upland areas, where not developed, consist of palmetto, scrub oak, brush, and many of the same Halophytes as grow on ocean dunes.

The upland drainage in this area is filtered through natural vegetation before reaching the river. The upland canals in this area are few and not a problem to the receiving waters at this time. The barrier beach area between the Indian River and A1A in south Brevard, and adjacent

General Description (Continued)

to the south shellfish area primarily consists of large tracts of undeveloped vegetated land. Such natural areas have maximum percolation capabilities.

In the future, as the South Beaches urban development increases, urban runoff problems will have to be addressed if the county is to maintain and enjoy its shellfish harvesting capabilities.

The west shoreline is a more developed area with single family homes and the shellfish industry-associated development. There are numerous private and commercial docks having access to water and the shellfish harvesting areas.

There are three fresh water creeks in the area. Goat Creek, Trout Creek and Kid Creek located on the west shoreline, are a source of fresh water to the area shellfish beds. The above creeks are classified as Class 2 waters, by the Department of Environmental Regulation.

There are no causeways or bridges within the designated shellfish harvesting waters.

The Inland Waterway is located at mid-river, closer to the western shoreline. At the Grant Island area, the waterway is cut close to the west shoreline amidst the oyster leases. An ever present source of contamination from waste disposal of Inland Waterway watercraft exists.

General Description (Continued)

Numerous spoil islands dot the length of the river parallel to the Inland Waterway channel. Several large "natural" islands, mostly created by required drainage ditches for the Brevard County mosquito control activities, also exist in this area. These projects were conducted in the late 1940s.

The most noteworthy fresh water inflow is the Sebastian River, where subtle color changes and increased turbidity indicate circulation patterns in the Indian River.

Historical Data

The Trustees of the Internal Improvement Trust Fund designated this area as an aquatic preserve with the following quoted description: "This is a biological preserve intended to protect that portion of the Indian River from Cape Malabar to Sebastian Inlet. This is an important water fowl and wading bird area, with wintering waterfowl population estimated as high as 200,000 birds. It is also important as a sport and commercial fishery and is the best oyster producing area in Brevard County ...."

The Department of Environmental Regulation assigned the area as Class 2 waters, precluding the disposing of certain pollutant and domestic waste.

Following an extensive shoreline survey, the Department of Health and Rehabilitative Services approved of this section as a conditional use shellfish harvesting area. Extensive monthly sampling programs safe-

Historical Data (Continued)

guard the quality of these waters for shellfish harvesting.

The above area waters, along with the Mosquito Lagoon portion of Area 7, have the highest designated water quality classifications in Brevard County.

AREA 5

RESULTS - GROUNDTRUTH

The submerged eastern portion of the Indian River in Area 5 is a sandy area with dense seagrass growth and highly productive clam beds. Although oyster beds also are located within this section, the sandy bottom is conducive to the growth of clams (Mercenaria mercenaria.) A gradual slope, predominantly sand and grass bottom and other appropriate conditions may be responsible for the above.

Except in certain pockets, there is little evidence of siltation in this area. Numerous stands of cord grass (Spartina alterniflora) seem to be increasing in the land-water interface of this shoreline. The first grass zone Ruppia maritima appears seasonally in the 0.5 meter depth zone. The Diplanthera wrightii - Syringodium filiforme zone is the next area and extends from 0.5 to the 2 and 2.5 meter depth zone. A fourth seagrass, Thalassia testudinum has been slowly establishing north of the Sebastian Inlet. This seagrass has appeared in several free stands; one in the shallow zone adjacent to the shoreline and two or three in mid-river. The presence of this seagrass had not been detected in the same area water the last four previous years and is an indication of a new seagrass establishment, or possibly a cyclic reestablishment. In either case, due to the physiological conditions of Thallasia, its presence is significant.

AREA 5

RESULTS - GROUNDTRUTH

A fifth seagrass Halophila engelmannii appears in non-specific zones intermingled with other seagrasses.

The Ruppia maritima zone, appearing in the shallowest areas has a late April, to August or early September season.

Diplanthera wrightii and Syringodium filiforme are seasonal seagrasses and, on this shoreline, present one of the most dense seagrass beds in the entire Indian River. The degree of this density is a function of the seasons.

The eastern shoreline water column has better visibility; hence, more light penetration. The aerials reveal depth features up to two meters depending on the season. The deep areas including the Inland Waterway channel appear uniformly dark on the color IR transparencies.

The imagery reveals several dark zones in the center of Area 5 indicating areas deeper than three meters in depth from 200 meters to 1600 meters wide, and several kilometers in length. The areas having depths approximately three meters plus, include the Inland Waterway channel which runs north-south through the length of Area 5, south shellfish area. With the specific turbidity loads, the imagery does not reveal river bottom features in the above-mentioned zones.

AREA 5

RESULTS - GROUNDTRUTH

The increased visibility on the east shoreline may be attributed to the heavier grassbeds and a nutrient uptake route through the macroalgae rather than the phytoplankton.

The seaweeds in this area, not restricted to a particular zone, established on occasional seashells or rocks, have their predominant holdfast on the seagrasses. Epiphytic seaweed growth on algae blades is abundant and constitutes a significant portion of the total weight of the seagrasses within this shoreline.

The western shoreline is a more rocky, less grassy and deeper area more conducive to the growth of oysters. The majority of the commercial shellfish beds are located on the west sides of the river.

A long chain of spoil islands, mostly created by the excavation of the intracoastal waterway, runs parallel to the waterway and close to the shoreline. Covered with Australian pines and various other vegetation, some have created significant rookeries for the now scarce and endangered Brown Pelican.

The seagrass zonation within this area is similar to the eastern shoreline in that Ruppia maritima occupies the 0.5 meter depth zone and numerous stands of this seagrass appear around the spoil island. The

RESULTS - GROUNDTRUTH

Diplanthera-Syringodium seagrass zone extends further out in deeper waters, respectively, to one meter and 1.5 meter zone. All in all, barring the spoil islands, seagrass activity in this portion of the river is minimal and grassbeds are more sparse with less density. Seaweeds abound whenever a suitable substratum is afforded. Oyster beds in this area are not uniformly dense. Oyster cultivation on the leased areas dictates the degree of density. Phytoplankton loads in this area appear heavy and thus increase water turbidity. The above loading may be due to less macroalgae growth, and a predominantly wind-mixed water column. The accelerated phytoplankton activity in turn provides adequate nutrients to promote shellfish growth.

The laboratory results do not demonstrate substantial seasonal phosphate and nitrate level fluctuations. Surface salinity averages at 25.7 ppt, with a range of 10.00 ppt (lowest) to 37.2 ppt (highest). The summer chlorophyll *a* profiles are somewhat higher than the winter profiles and average at 9.2 mg/m^3. The pH range is between 6.5 and 8.2.

The phytoplankton profile is more diverse and the counts higher in the summer months.

AREA 5

RESULTS - GROUNDTRUTH

Several cases of dinoflagellate blooms have occurred in this area and in this case the bloom has been in an approximate 70 meter wide by 300 meter long area. No toxic shellfish poisoning has been reported in this area within the period of this investigator's survey.

Seaweeds in this area are diverse and substratum specific. Predominantly, such substratum is provided by the oyster beds on the western sides and the seagrasses on the eastern sides of the submerged river areas. There is no specific zonation for the different species of seaweeds. The channel bottom and the areas in excess of three meters support a lush growth of Gracilaria verrucosa and Hypnea-cornuta.

There are 67 species of seaweeds in this study area; 36 of these are Rhodophytes, 6 phaophytes and 25 chlorophytes.

The Sebastian Inlet seaweeds are a more true representation of an intertidal area. The brown (phaeophyta) algae ration is higher in this area and the species are more true to the textbook form.

AREA 5

RESULTS - IMAGERY

A roll each of color and color infrared summer season imagery was taken in March of 1974 using the KA-2 camera with a 6" lens. The flight altitude was at 6,000 feet. The winter imagery was taken in late January of 1975 using a Zeiss camera. The film utilized for this flight was Kodak number 2448. For multispectral color, and Kodak number 2443 for color IR. The imagery was obtained at an altitude of 6,000 feet.

The seagrass beds were delineated on vegetation maps. The maps were prepared using the 6-inch square section of each frame in a mosaic fashion. The grassbeds are readily distinguishable upon direct examination of the aerials. Grass densities of less than approximately 30 blades per square meter are not distinguishable from sandy areas.

With the existing phytoplankton loads, the maximum water penetration capability was about 1.5 meters. Beyond that depth, the light penetration was not adequate to delineate grasses from non-grass areas. The groundtruth data, however, indicates that the grass zones of Area 5, where water depth exceeds 1.5 meters, is beyond the imagery delineation capabilities.

There are various underwater and emergent sandbars in different stages of formation. The imagery seems quite sensitive in indicating the above, and the circulation patterns associated with sandbar formation.

AREA 5

RESULTS - IMAGERY (Continued)

Precluding the string of fill islands created by the dredging of the inland waterway, there are two prominent sandbar areas rapidly accumulating sand, and are obviously increasing.

One such sandbar is at the Palm Bay point and consists of an island rapidly accumulating sand and increasing in size, towards the western shoreline. Within the last few years, the two land areas have built up and met, creating a sandbar.

The aerial photos very effectively predicted the above by indicating specific sand patterns under water.

These same sand patterns indicate a new area in the process of forming a future sand bar on the northeast shoreline of Area 5 as indicated on the aerials.

The dredged areas such as canals, are easily detected as indicated on the maps. The above areas have a distinguished border and appear opaque and uniformly dark. Their more or less geometric configuration also helps to identify them as canals.

The Inland Waterway appears generally dark and has no obvious boundaries except where the borders consist of seagrasses. Thus, within the 1.5 meter depth the rocky areas, as well as hard oyster bottoms, appear as small, semi-circular patches of dark against a background of lighter color grass or sand. These areas are most often covered with seaweeds.

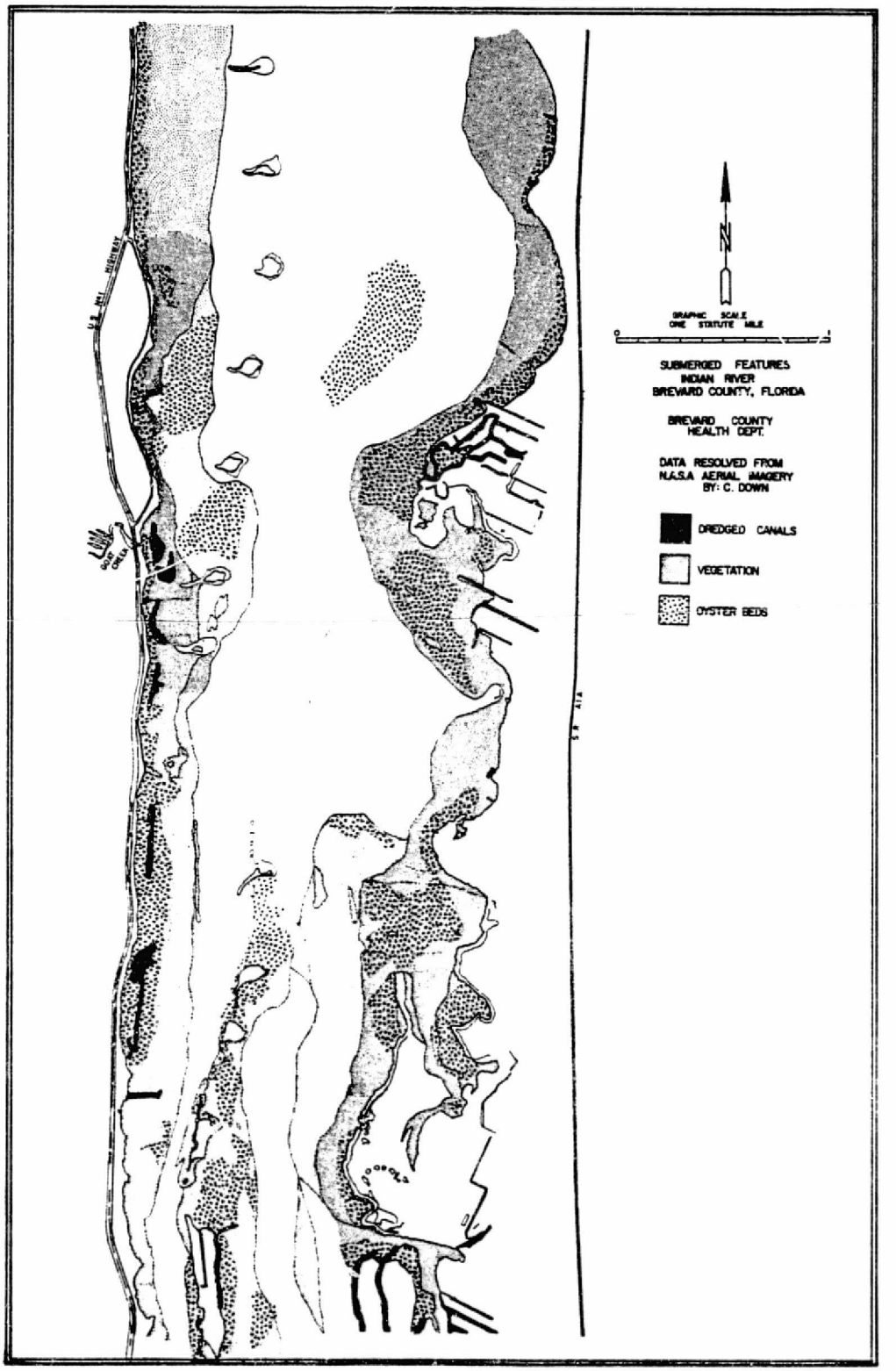
AREA 5

RESULTS - IMAGERY (Continued)

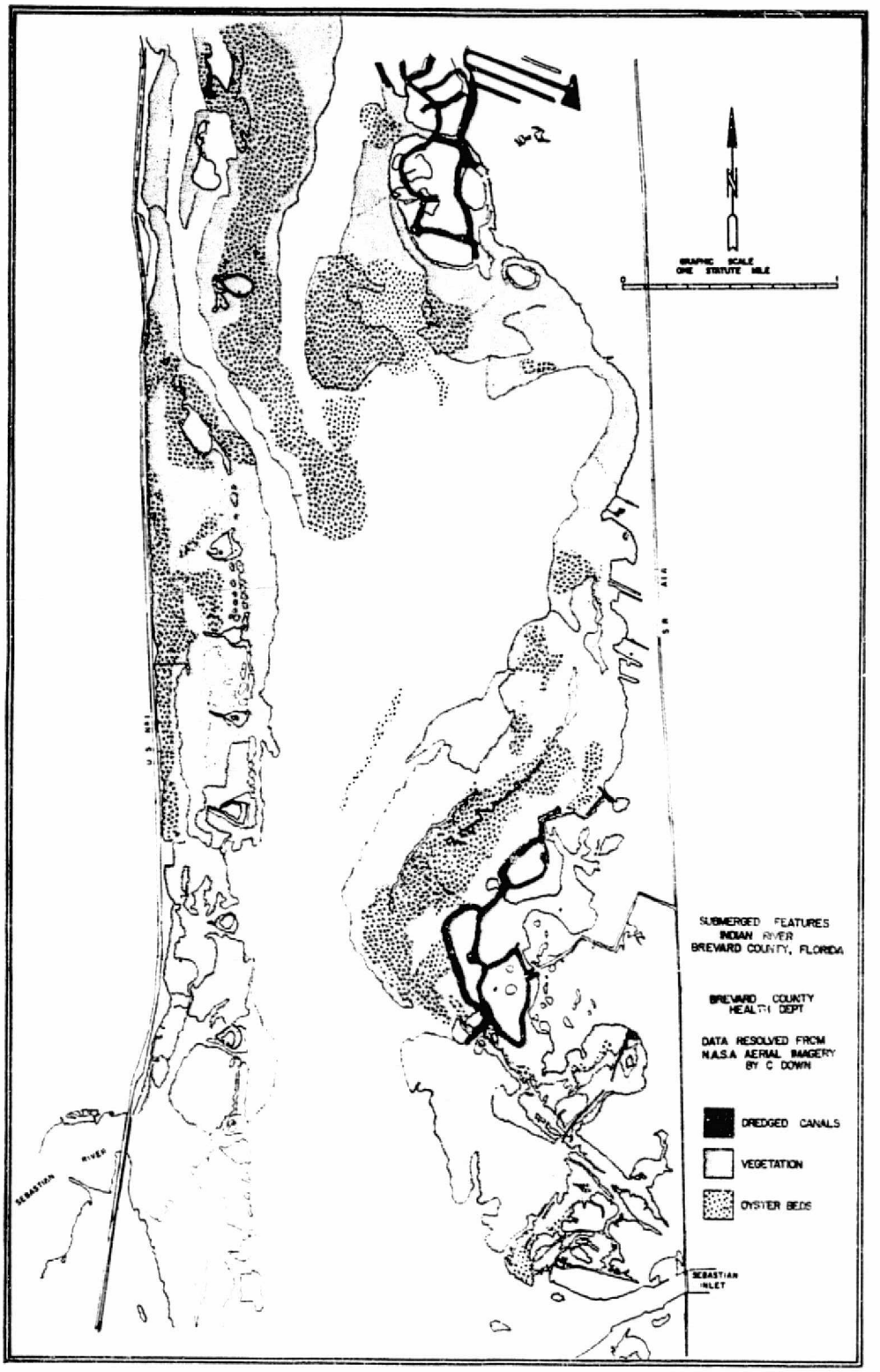
Barring the seagrass specific epiphytes, seaweeds take hold fast on rocks, oysters and other hard substratum such as pilings or other incidental hard surfaces. The oyster harvesting areas with more oyster turnover traffic and harvesting have a much more sparse seaweed growth. These clear and more dense oyster stands were used to develop signature for oysters. This signature was obtained using thw IM 100 and pertains to areas of 3 feet (1 meter) or less in depth.

The winter imagery has better depth penetration which may be due to clearer water. Since the Zeiss camera was used for the winter season imagery, the above observation may be a function of the camera and cannot be verified without further data collection.

AREA 5 MAP



AREA 5 MAP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GRAPHIC SCALE
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INDIAN RIVER
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HEALTH DEPT
DATA RESOLVED FROM
N.A.S.A AERIAL IMAGERY
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DREDGED CANALS
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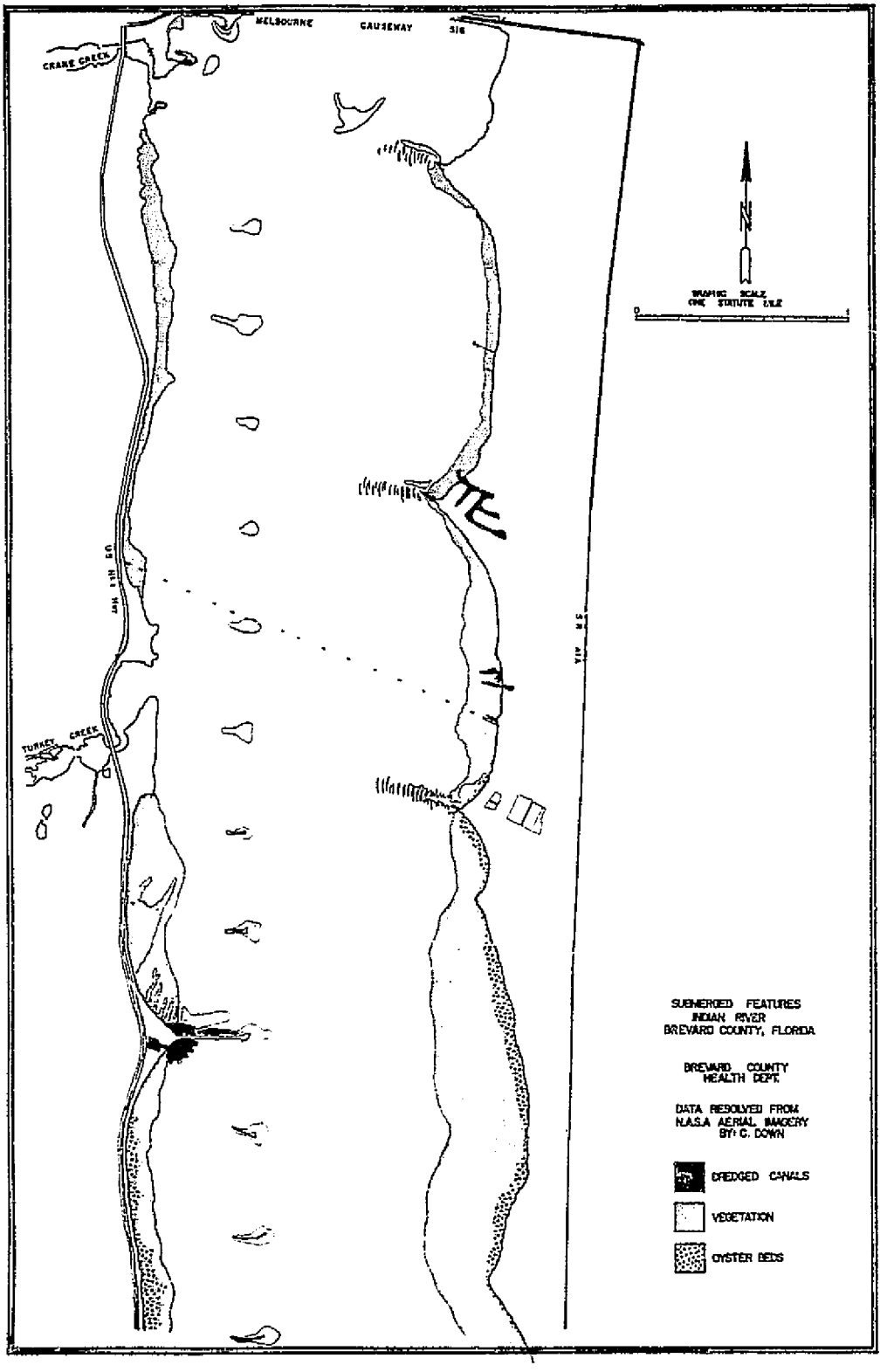
SEBASTIAN
RIVER

AREA 5 MAP



AREA 6

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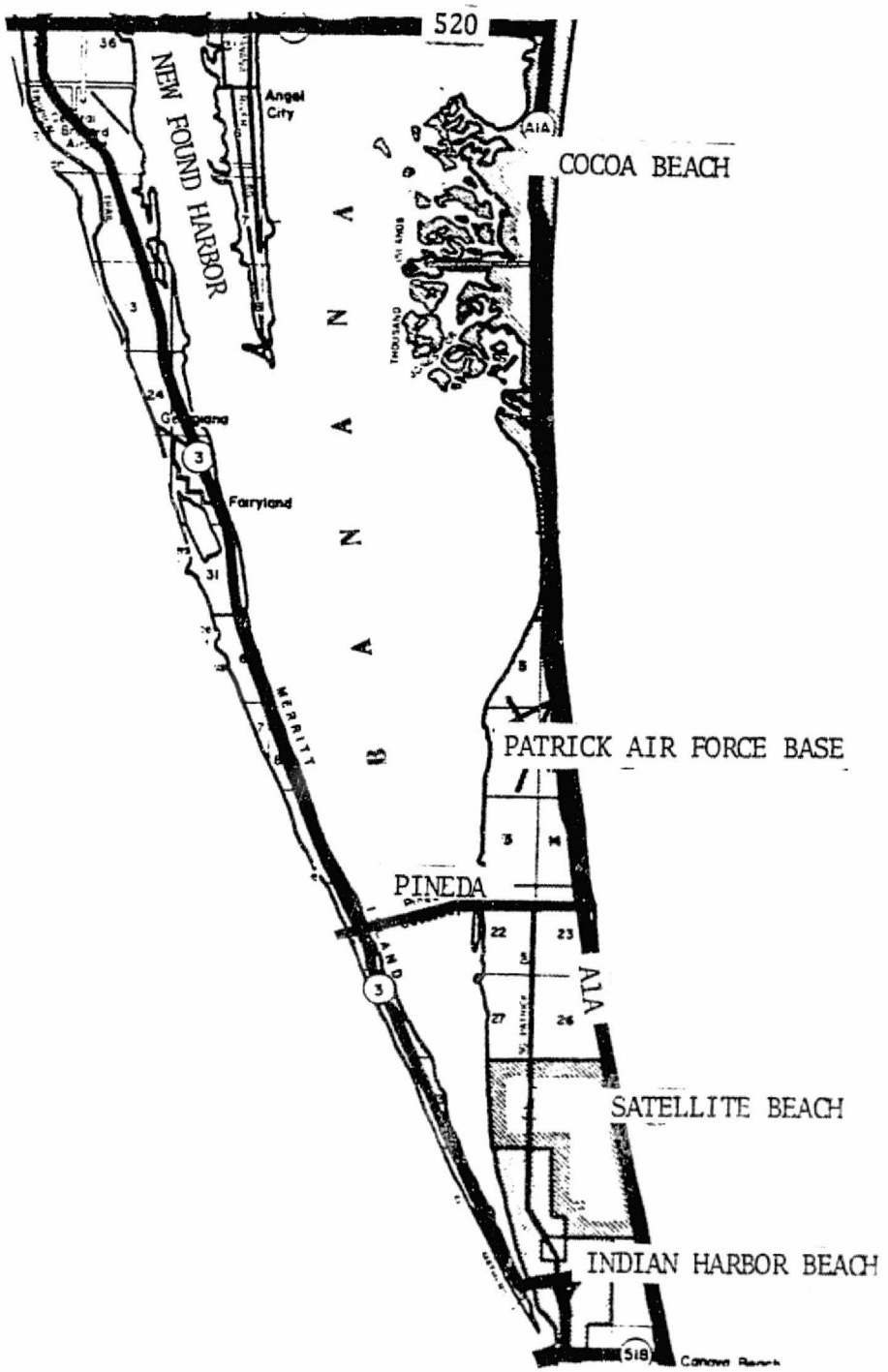


AREA 6

AREA 6

General Description

Area 6 is located in the Banana River between the 520 Causeway in the north and the southern tip of Merritt Island in the south. This section is approximately 15.5 miles (25 Km) long, and 2 to 3 miles (3 to 5 Km) miles wide. A designated Aquatic Preserve, this area is shallow, grassy and a prominent fish and shellfish spawning ground.

The City of Cocoa Beach borders the northeastern portion of the Banana River. Cocoa Beach owns and operates a three million gallon a day sewage treatment plant with secondary treatment capabilities. This plant, currently operating at 80 percent capacity, is the source of a golf course irrigation which uses 15 percent of the final treated effluent. The balance reaches the Banana River.

The Patrick Air Force Base main sewage treatment plant is located on the Base and the Capeheart Plant at the 404 (Pineda) Causeway. The design capacity of each approximates at one million gallons/day currently operating each at roughly 75 percent capacity. The final effluent from these plants reaches the Banana River. The South Patrick plant is owned and operated by Brevard County. This 2-million gallon a day plant operates at approximately 85 percent capacity and serves the Satellite Beach area. The final runoff from this secondary treated effluent is also discharged into the Mosquito Control canal also known as the Grand Canal. This

General Description (Continued)

canal is separated from the Banana River by a series of spoil islands approximately four miles long.

A fourth sewage treatment plant facility, the Indian Harbor Beach plant, has a capacity of 0.675 million gallons a day. This plant, however, is totally contained in evaporation-percolation ponds and does not discharge to the Banana River. The Indian Harbor Beach plant operates at 100 per cent capacity.

The north boundary of Area 6, the 520 Causeway, was built prior to 1950 to give access to the beaches. There are two relief bridges at the east and west ends of the filled portion of the causeway. These bridges afford limited water circulation within these areas of the Banana River.

The northwest shoreline of Area 6 consists of south Banana River and Newfound Harbor Drive. Both areas are predominantly single family homes with a portion of undeveloped land. Natural vegetation and lawns take the initial rain runoff impact in this area and the land development does not seem to have a significant impact on the waters. A commercial crabmeat packing company located on the northwest corner of this area is a self-contained plant where the crab shell and discards are processed for animal food and not disposed of in the Banana River.

The Newfound Harbor portion of Area 6 consists of almost exclusively single family homes and large estates. These low density areas maximizing

General Description (Continued)

on vegetated gardens and lawns form an excellent buffer zone for the receiving waters of this area.

The east shoreline of the Banana River has two distinct features. One, the area has 53 manmade canals within the cities of Cocoa Beach and Satellite Beach. These canals, representing artificial, unvegetated underwater areas have historical proof of low water quality and associated problems. Two, the mass of islands in Cocoa Beach known as Thousand Islands, is a unique feature of this area reminiscent of a salt marsh. Extensive mosquito control activity has transformed the low marsh vegetation profile to one of a transitional to upland nature. The area still abounds with mangroves and has been a subject of several intensive studies. There are extensive shallow areas adjacent to these islands, serving as marine nursery grounds.

There are substantial dredged areas of up to five meters in depth adjacent to, and reaching west of Patrick Air Force Base. These sections appear uniformly dark on the color and the color infrared imagery.

The Pineda Causeway, built in 1970, has had a substantial detrimental effect on the biota of both the Indian and Banana Rivers. The siltation from the project covered up significant areas of seagrass beds causing their destruction. A loss of water circulation due to the fill requirements of the Causeway has also had short and long range effects in the ecological profile of this area. There is rapid and substantial silting taking place at the southwest junction of the Causeways, both at the

General Description (Continued)

Merritt Island and the mainland sites.

Historical Data

The Trustees of the Florida Internal Improvement Trust Fund designated this portion of the Banana River as an aquatic preserve.

AREA 6

RESULTS - GROUNDTRUTH

Where not developed, this area resembles Area 2 in having a gradually descending shoreline. The immediate zone adjacent to the shoreline and averaging three meters in width, is no more than 30 to 45 centimeters deep and is free of seagrasses.

This area receives the initial impact of the upland runoff and is subject to frequent dinoflagellate blooms. The prevailing winds drive and accumulate seagrasses and seaweeds ashore to decompose within this zone. This is an annual occurrence and takes place at the end of the summer season.

Many free stands of cordgrass (Spartina alterniflora) cover the land-water interphase in Area 6. Their number and extent is on the increase.

The Ruppia meritima zone is the shallow seagrass zone and extends to a depth of 0.5 meter. The Diplanthera wrightii and Syringodium filiforme zones extend to 1.5 and 2.0 meters in depth.

The fourth seagrass Halophila engelmannii is not depth specific and grows in patches at random.

The water chemistries in the Banana River proper areas compare favorably with the data from Area 2. Dissolved oxygen levels range from 4 to 9 parts per million. Average phosphates were approximately 0.65 parts per million. The nitrates averaged 0.49 ppm. Salinities range between 23.7 and 38.2 parts per thousand and have an average of 27.0 ppt. The

RESULTS - GROUNDTRUTH (Continued)

nutrient data reflects areas in the vicinity of Cocoa Beach. Seasonal chlorophyll *a* values range from 14.4 to 8.0 mg/m^3 in the summer and 4.8 to 8.8 mg/m^3 in the winter. Average summer chlorophyll *a* values are 11.5 mg/m^3 with the winter values at 6.5 mg/m^3. pH ranges are from 7.5 to 8.5 with an average of 8.0. There is no appreciable seasonal difference in the pH values except for a slight reduction in the summer season. The phytoplankton counts average almost the same for both summer and winter seasons. This area exhibits frequent and patchy dinoflagellate blooms.

The area seaweeds are substratum specific and not depth dependent. Their holdfast consists of oyster shells, rocks, coarse sand and seagrasses. Where not in the photic zone, the seaweeds consist mainly of sinking drift algae.

The area seaweeds are seasonal and more abundant in the summer. The epiphytic seaweeds constitute a prominent portion of the macro-algae system.

There are fifty-one species of seaweeds in this area. Thirty-three of these are Rhodophytes and 18 Chlorophytes.

AREA 6

RESULTS - IMAGERY

A roll each of color and color infrared imagery was taken in March of 1974 and winter imagery was obtained in January of 1975.

The north part of Area 6 has extensive seagrass beds in the section adjacent to the 520 Causeway and mostly in shallow waters in 1 meter depth.

The 1000 Islands, once an area of substantial grassy marsh and shallow vegetation, has been extensively diked to control water levels for mosquito control purposes.

The above imagery depicts the dikes and the shallow vegetated areas inside and outside these dikes.

The dredged sections include approximately 31 canals. A perimeter canal connects these canals to a marked channel. This channel runs parallel to the shoreline of the south Banana River Drive, Angel City area.

South of Cocoa Beach and adjacent to Patrick Air Force Base, the imagery shows a distinct and uniformly dark section of several square miles, where extensive dredging had taken place years ago in connection with a seaplane base. This area was not depicted in black on the maps, as in canals and other dredged areas. This large section denuded of seagrasses, extends as far south as the Pineda Causeway.

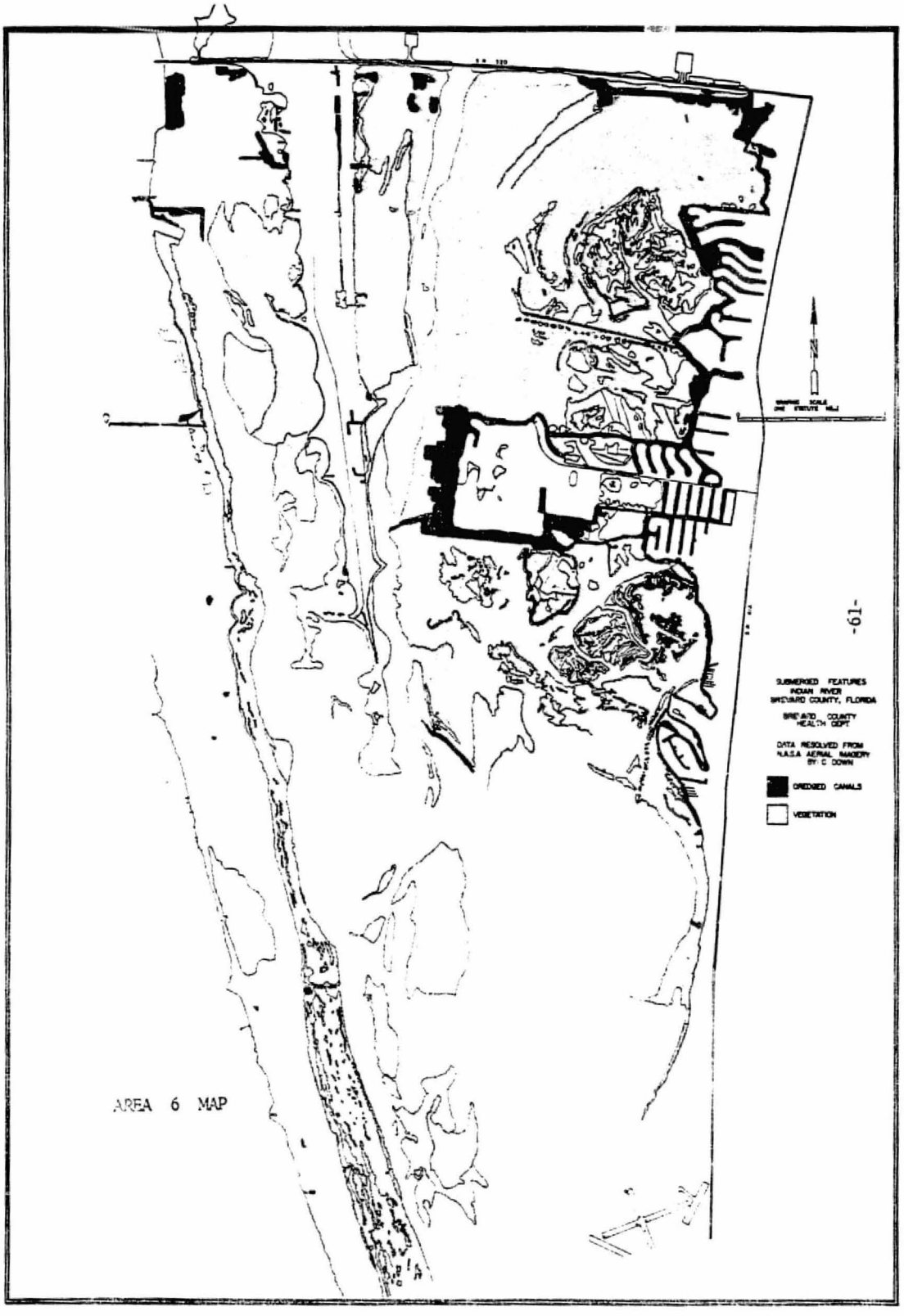
AREA 6

RESULTS - IMAGERY (Continued)

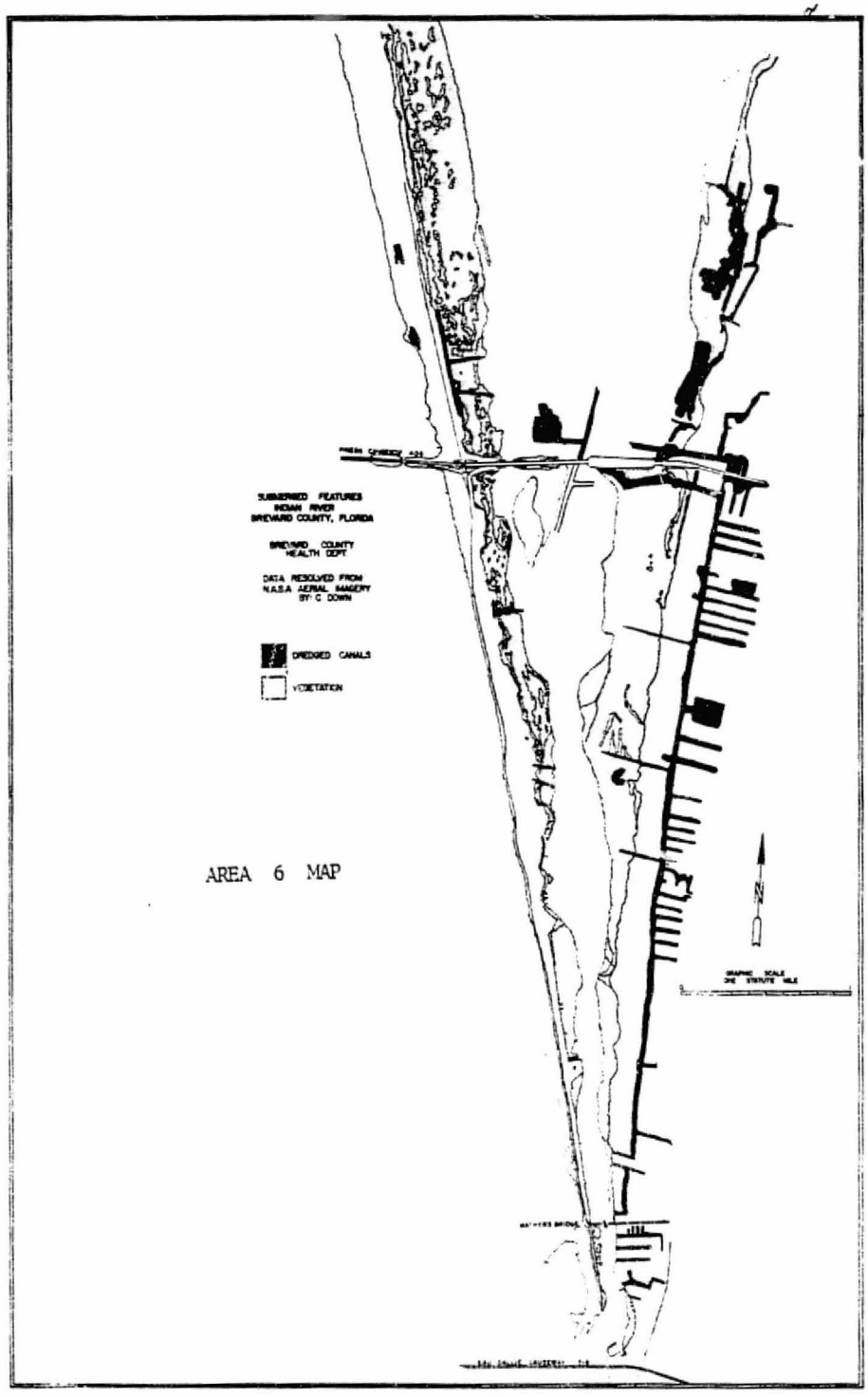
The area south of the Pineda Causeway has approximately 29 canals connected by a perimeter canal. These and other dredged areas are depicted on the appropriate maps.

MAPS

AREA 6



AREA 6 MAP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BREVARD COUNTY, FLORIDA
BREVARD COUNTY
HEALTH DEPT.
DATA RESOLVED FROM
N.A.S.A. AERIAL IMAGERY
BY C. DOWN
DREDGED CANALS
VEGETATION
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GRAPHIC SCALE
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AREA 6 MAP

AREA 7

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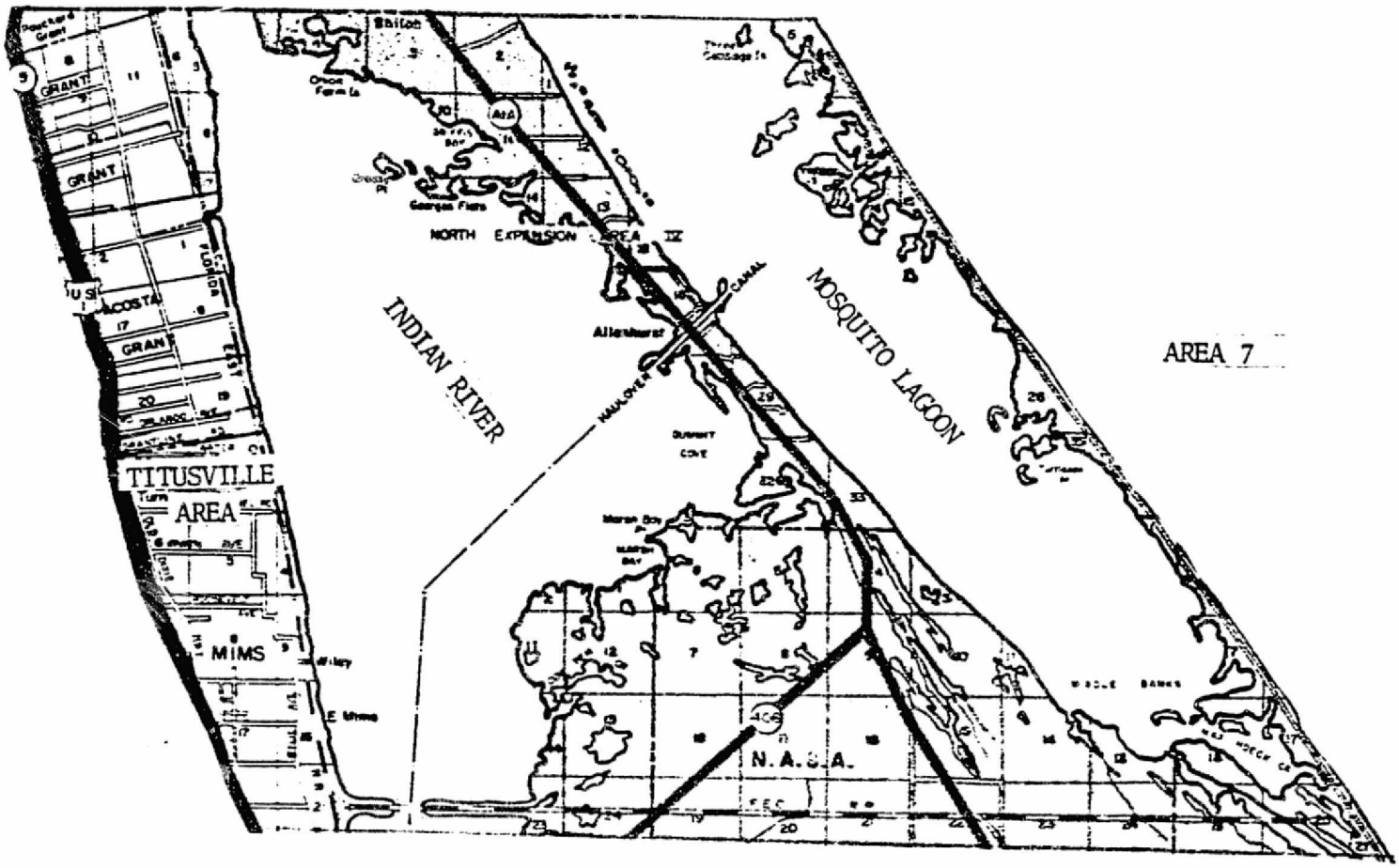


AREA 7

General Description

Area 7, located in north Brevard County, involves two bodies of water: the Indian River and the Mosquito Lagoon. These two bodies of water are connected by the Haulover Canal.

The Indian River, Area 7, begins in north Titusville, at the FEC railroad causeway and bridge. Located a little over two miles north of the Indian River 402 Causeway, this study area is north and outside of the main urban areas of the City of Titusville. A sewage treatment plant with secondary treatment capabilities, is located on the west shoreline approximately 1.5 miles (2.4 Km) south of the railroad bridge. The Class 2 waters beginning slightly north of the FEC bridge extend to the Brevard-Volusia County line.

The western shoreline of the Indian River consists of rural areas and agricultural lands. Sparsely populated, the area consists of scattered residences and orange groves. The quality of the storm water runoff from agricultural activities is not studied in this area. Several small creeks have direct fresh water input into the waters adjacent to the western shoreline of the river.

Eastern shoreline consists of the Merritt Island refuge and has been extensively impounded and diked by Brevard County Mosquito Control. The impoundments formed within the Merritt Island National Wildlife Refuge

General Description (Continued)

area are controlled by the refuge, and their water levels are periodically adjusted by direct intake from or discharge to the Indian River. A series of spoil islands parallel the intercoastal waterway through the Haulover Canal.

Barring the waterway and the 2 to 5 meter deep areas where imagery does not reveal bottom characteristics, the river is vegetated with seagrasses.

The northwestern portion of the Indian River and the area adjacent to Turnbull Hammock has not been ditched and diked. This area has intermittent emergent cordgrass (Spartina) stands, representing a typical marsh, as it existed prior to the present extensive mosquito control activities. Turnbull Creek and the Turnbull Hammock area is a source of fresh water to the northernmost part of the Indian River. The north Brevard County Area 7 waters are designated as Class 2 shellfish harvesting waters.

The south portion of Mosquito Lagoon is the second body of water in Area 7. Many mangrove bordered islands form the eastern shoreline of this section. The western shoreline is bounded by orange groves within the Merritt Island National Wildlife Refuge. Also, the new federally established Canaveral National Seashore Park borders this area. The inland waterway channel constitutes the deeper areas of this body of water. Salt ponds, duck ponds, and citrus groves contribute to the

General Description (Continued)

quality of the storm water runoff sources of these river waters.

The Mosquito Lagoon grassbeds are extensive and rather uniform in density. This and other biological features helped establish Mosquito Lagoon as an aquatic preserve.

The seaweed species diversity in Area 7 is one of the highest in Brevard County, and second only to Sebastian Inlet. The inlet has suitable salinities allowing for survival of off-shore as well as inshore, species.

AREA 7

RESULTS - GROUNDTRUTH

Dense stands of seagrass Halophila engelmannii constitute a unique feature of this section. Growing in patches exceeding 20 square meters in size, this seagrass may appear in pure stands, but predominantly grows in conjunction with Syringodum filiforme or Diplanthera wrightii.

H. engelmannii grows on sandy areas, where the bottom sediment may be predominantly white sandgrains. It also abounds in darker bottom sediment where soils constitute finer particles, and more organic matter. Thus, in Area 7, H. engelmannii appears to be neither depth dependent nor substratum specific.

The Ruppia meritima, Diplanthera wrightii and Syringodium filiforme zones are similar to the other areas. Mosquito Lagoon has a much more uniform grass cover; this uniformity is both in grass density and average grass blade size.

The most remarkable difference between Area 7 and other areas seems to appear in the salinity data. The average summer salinity of this area is 30.7 parts per thousand, with a range of 23.9 ppt to 36.8 ppt. The winter salinity averages at 32.6 ppt, with a range of 25.0 ppt to 36.7 ppt. The higher winter ranges in salinity are expected, since winter is the dry season.

The above higher salinity waters may be a factor in the presence of invertebrate species such as chiones, gorgonians and specific species

of sea anemonies. The above organisms are usually found in more tidal areas with higher salinities.

The average summer temperature in this area is 28.5°C with a range of 21.0°C to 38.0°C. The winter temperature average is 24.6°C with a range of 19.4°C to 29.4°C.

The dissolved oxygen average for the winter months is 7.0 with a range of 5.5 to 8.6 ppm. The summer dissolved oxygen average is 7.3 with a range of 5.5 ppm to 9.5 ppm.

The summer and winter pH ranges were quite similar and were approximately 7.8. The range was between 7.1 and 8.6.

The chlorophyll *a* values in the winter averages at 3.87 mg/m^3 with a range of 0.59 to 8.6 mg/m^3. The summer average is 7.9 with a range of 1.4 to 8.3 mg/m^3.

The slightly higher summer chlorophyll *a* values correspond with a slightly higher summer phytoplankton counts.

The area seaweeds are diverse and seasonal. There are 40 species of seaweeds recorded for the summer and 30 for the winter. Of the above total of 50 seaweeds, there are 40 Rhodophytes, 18 chlorophytes and 3 phaeophytes.

AREA 7

RESULTS - IMAGERY

The summer vs. winter imagery of Area 7 involved a camera change from a KA-2 to a Zeiss camera. As in the other imagery data, the Zeiss camera providing the winter season imagery appeared to produce better feature distinction and water penetration.

The imagery was recorded on Kodak 2443 film using a "minus blue" filter to block the blue radiation. The film recorded the green, red, and photographic infrared radiation each separately on one of the three dye layers on the film. Equipment in the NASA Data Analysis Facility allow the examination of each dye layer image individually or in any combination.

Examination of the individual image on each of the three dye layers often reveals details on one layer that is obscured when viewing the three layers simultaneously.

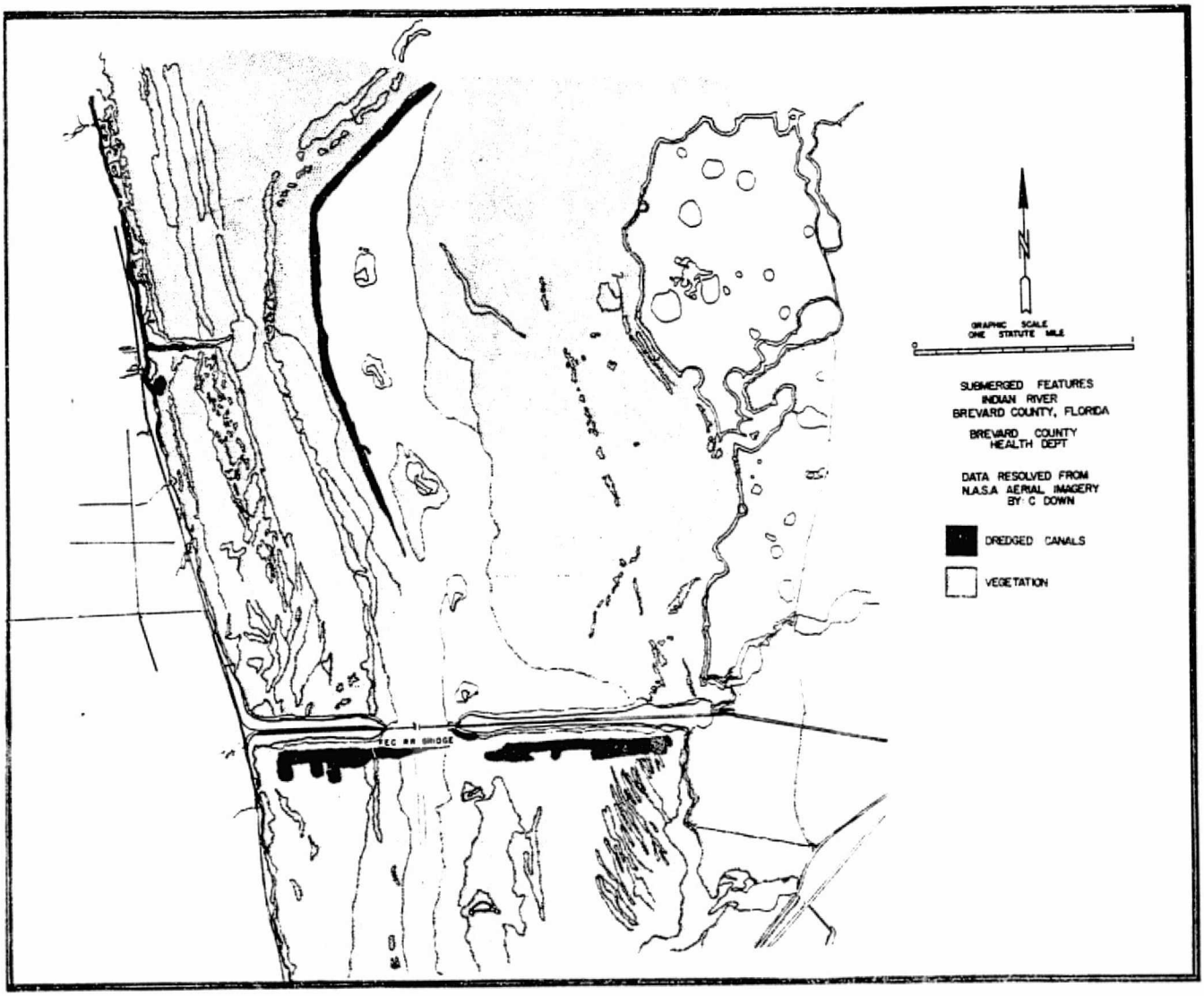
The Indian River section of the imagery revealed extensive Mosquito Control ditching and diking activities. The aerials also revealed no dredged residential canals. There are extensive grassbeds in this section of the Indian River.

The north end of the Indian River Turnbull Hammock area imagery had less underwater light penetration capabilities. Turnbull Creek tannin colored

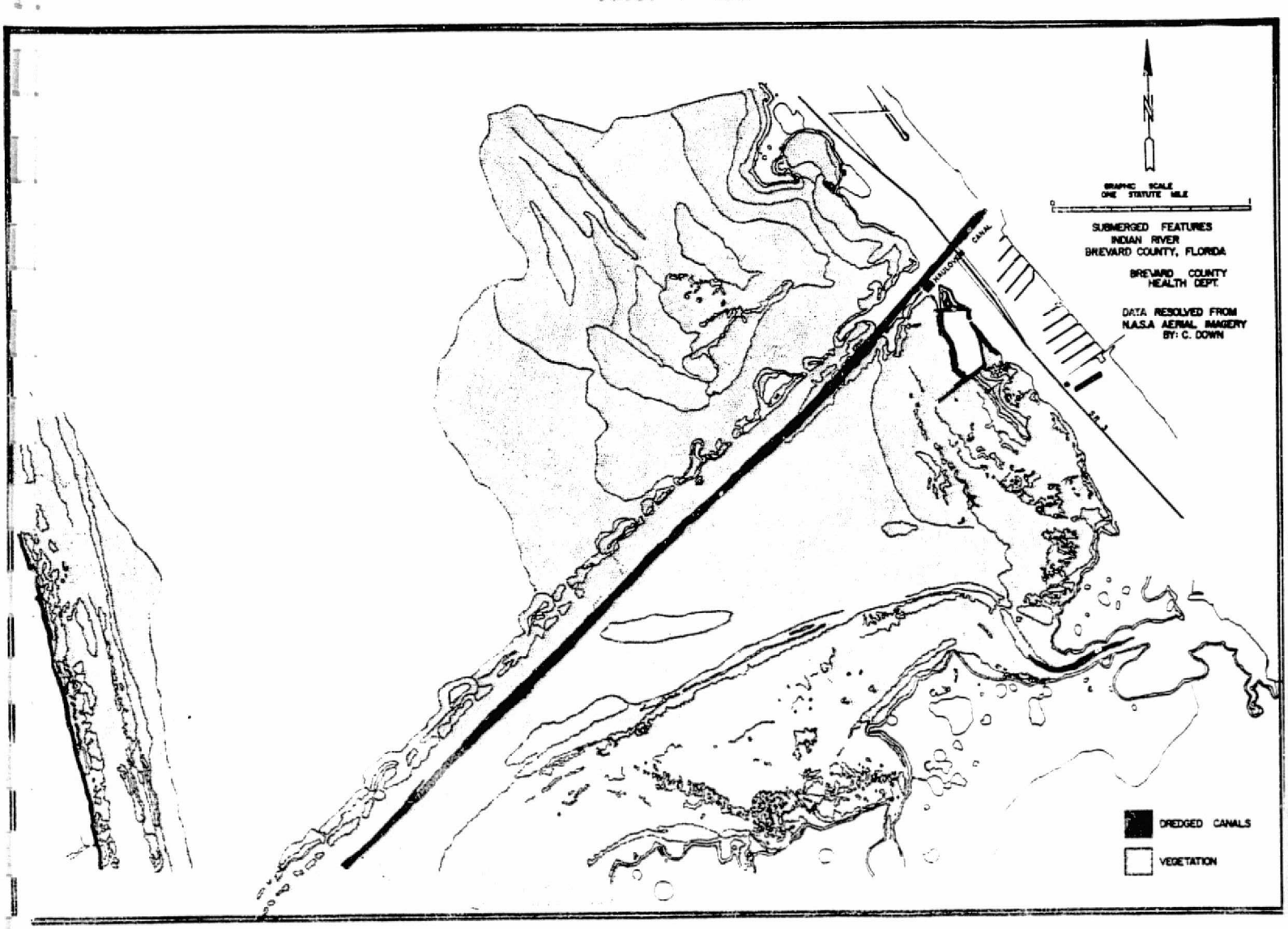
waters may have caused the above. The imagery stopped short of the northernmost end of the river and for mapping purposes, a set of aerials was borrowed from another agency to complete the maps.

There is considerable difference between the color reflectance of the Indian River and the Mosquito Lagoon on the transparencies. Since the timing and the processing of the imagery were uniform, the color difference is probably due to factors associated with the water conditions. Mosquito Lagoon has a detectable lunar tide action and usually higher salinities. The Mosquito Lagoon is also generally shallower than the Indian River. There is also a less phytoplankton load in the water column of the Mosquito Lagoon waters. This clearer water would appear a different color on the transparencies. The Turnbull Hammock tannins, coloring the north Indian River area, may also cause a color difference on the imagery. Any one, or the cumulative effect of the above reasons may account for the color reflectance differences of the imagery between the Mosquito Lagoon and the Indian River area.

AREA 7 MAP



AREA 7 MAP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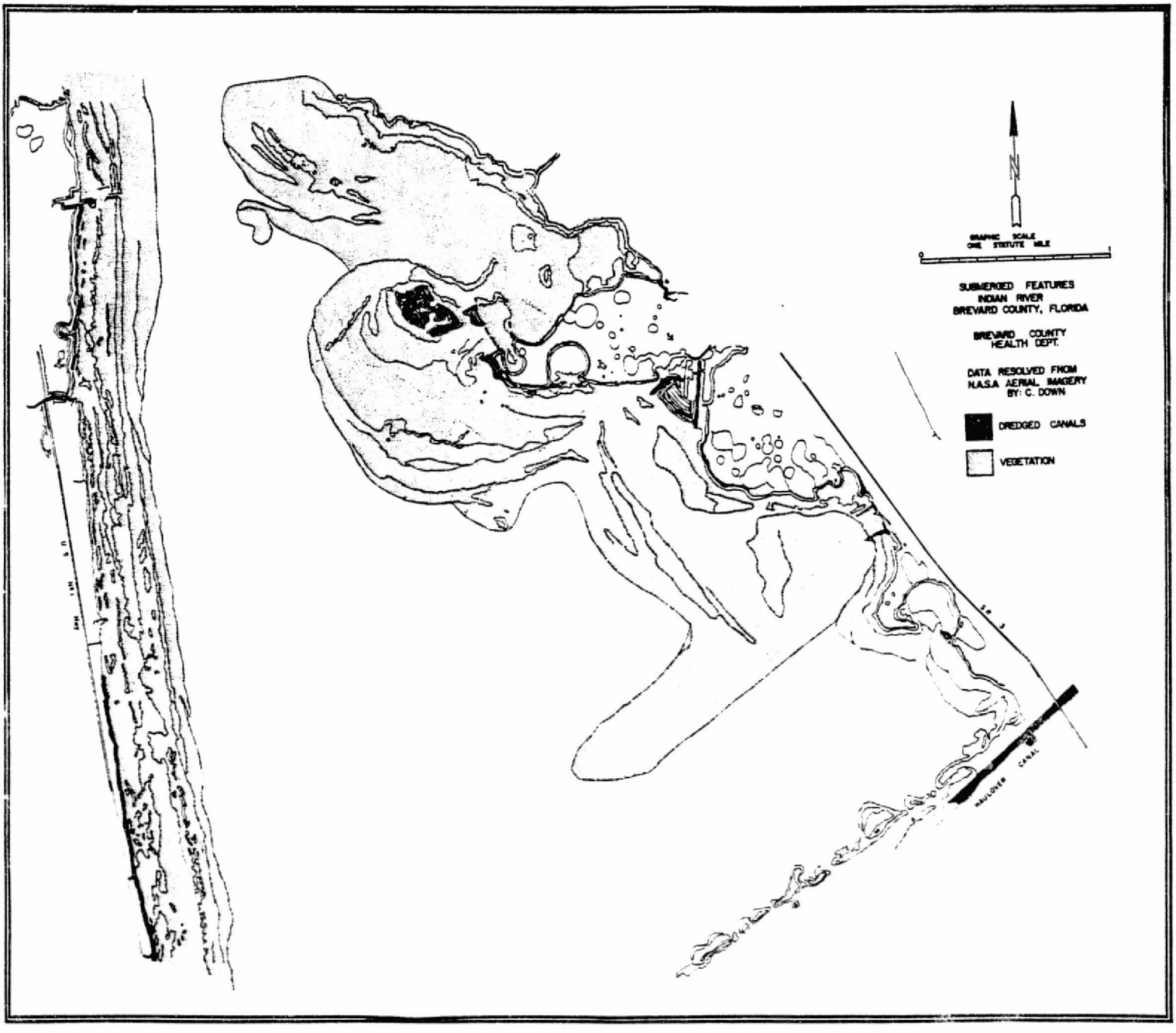
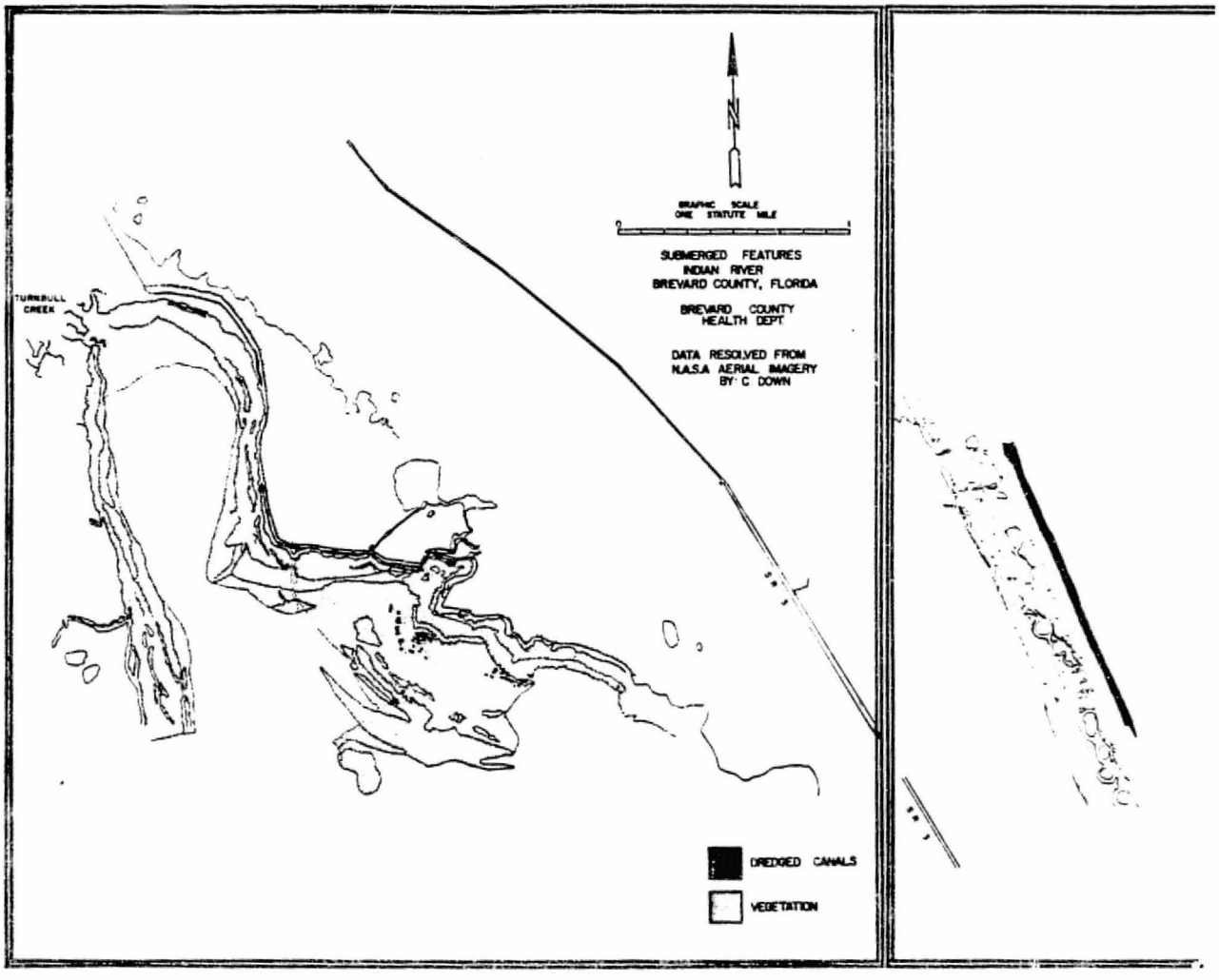
BREVARD COUNTY
HEALTH DEPT.
DATA RESOLVED FROM
N.A.S.A AERIAL IMAGERY
BY: C. DOWN
MALABAR CANAL
DREDGED CANALS
VEGETATION

AREA 7 MAP



AREA 7 MAP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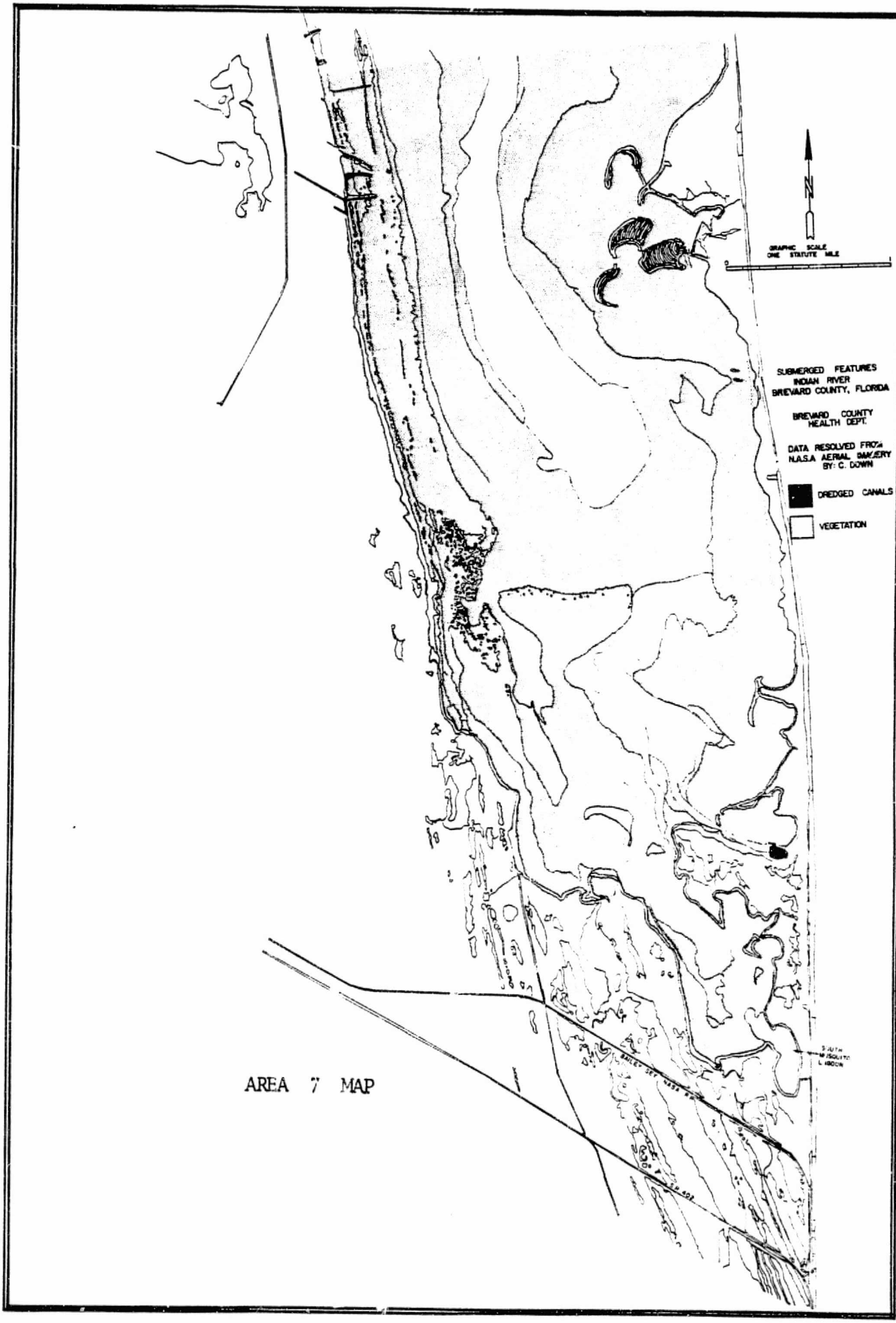
TURNBULL
CREEK
DREDGED CANALS
VEGETATION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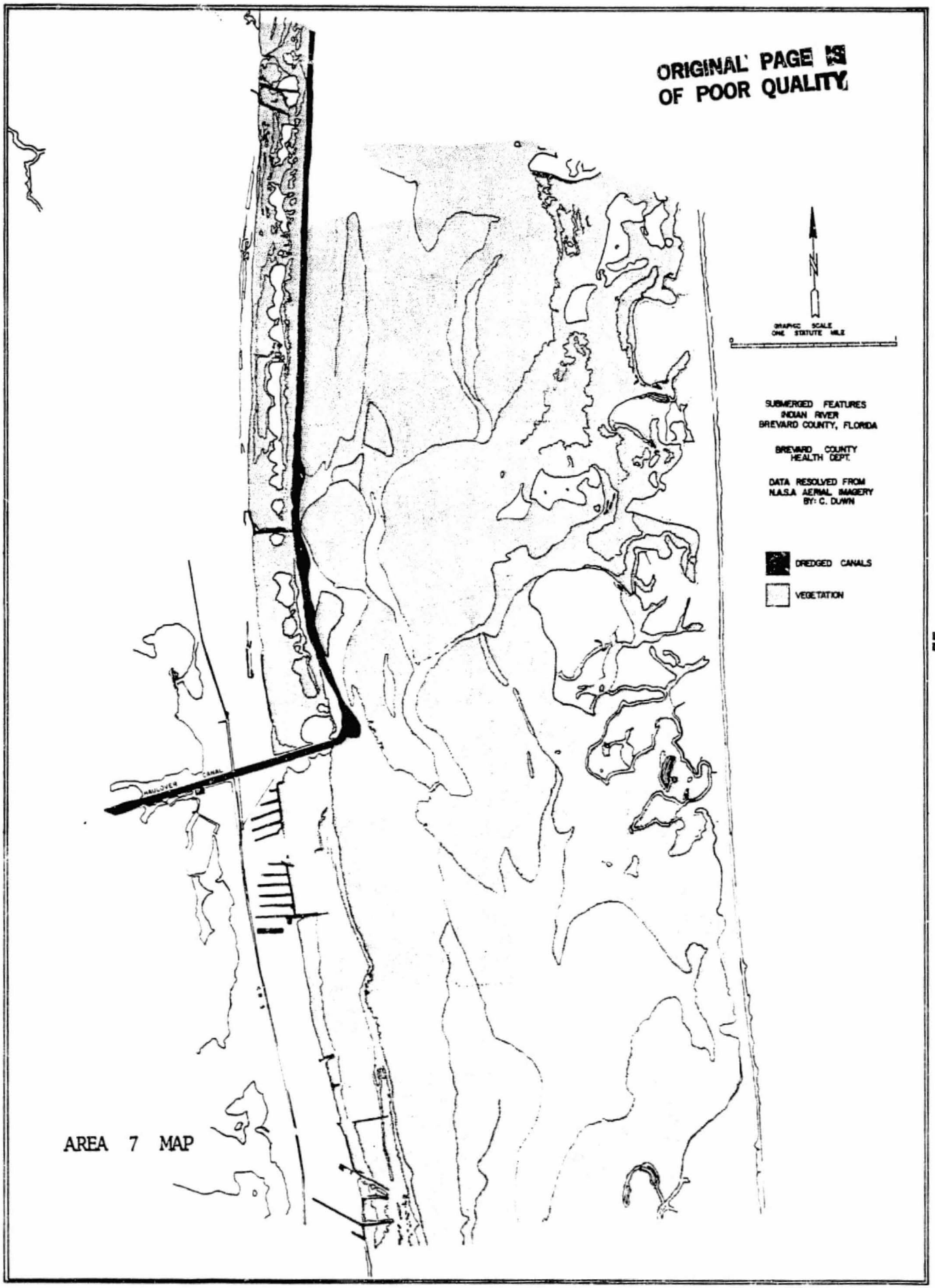
BREVARD COUNTY
HEALTH DEPT.
DATA RESOLVED FROM
N.A.S.A AERIAL IMAGERY
BY: C. DOWN
DREDGED CANALS
VEGETATION

AREA 7 MAP



AREA 7 MAP

DATA ANALYSIS

The following photoanalytic approaches, I^2S, color and color infrared were used with the following results.

The I^2S system consists of a 9" KA-2 aerial mapping camera equipped with a lens system that focuses the same image on each of the four quadrants of a 9" black and white aerial film. Kodak 2724, the four part lens system filters out all but a narrow part of the electromagnetic spectrum. The four filters are blue (0.410-0.470 NM); green (0.475-0.580 NM); red (0.590-0.690 NM); and near IR (0.740-0 .900 NM). The four 70 NM format images are processed and projected on a four channel optical projection which superimposes the four images on a rear projected viewing screen. The projector provides filters that can add a "false color" of blue, green, or red to each of the four black and white images. Controls on the viewer allow adjustment of the intensity at which each of the four images are projected onto the viewing screen. The false colors and projection intensities are manipulated to find the part of the spectrum where an area of interest can be most clearly viewed.

Within the scope of this project, the use of I^2S was determined to be limited. It is possible that the images did not provide adequate contrast for analyzing data involving underwater features. The I^2S black and white aerial film may be incapable to assess the underwater features.

Much effort was spent in data analysis using the Digicol initially, and the Image 100 later. The biggest factor in obtaining data from the above methods seems to be the quantity of turbidity in the water.

At a meter depth, the Digicol with certain settings picked up grassbeds and quantified them. At two meter depth, however, the machine could not distinguish between depth densities and grassbed densities. Microdensitometer slicing techniques, separating depth and density, seemed successful in Area 2 but did not work in Area 5.

The IM 100, because of the minimum area pixel requirements (one acre), had limited data analysis capabilities with the aerials acquired from low altitudes flights. As in the Digicol, after some experimentation, signature was developed for an oyster bed and a grassbed area. Applying the IM 100 data to another section of the river, however, did not produce the same results.

In other than underwater projects, color transparencies are believed by many field investigators to be best suited for studies requiring documentation of specific environmental features. The advantages of Kodacolor film include true color presentation of these upland features, where green plants appear green and red rooftops appear red.

Although underwater features such as grassbeds, etc., are visible on Kodachrome color aerial transparencies, their delineation to the naked eye, as well as through the instruments used, is less clear compared

with other films. This statement applies to this investigator's project with its specific project requirements. Since a great deal of underwater signature depends on light penetration, possibly, better results may be obtained using Kodachrome color film in areas having less turbidity or lighter phytoplankton loads than the subtropical Indian and Banana Rivers. The best use color transparencies, however, may be in detection and documentation of emergent vegetation such as wetlands and marshes, rather than underwater features.

The color infrared transparencies proved to be the most effective method for detection and documentation of underwater features in Brevard County waters. All underwater features were mapped using these IR transparencies. An extensive ground truth data collection program verified findings depicted on the maps. These trips involved some 62 biological sampling stations visited over a 5-year period.

The following underwater features were detected by direct examination of the color IR aerials over a light table, sometimes using a hand lens.

1) Seagrass beds, up to approximately 3 meters in water depth.
2) Substratum specific seaweeds and seaweed patches.
3) All dredged areas and canals.
4) The inland waterway channel, where dredged area neighbors shallows, less than 2 meters in depth.

5) Other navigable channels.

6) Oyster beds, where the depth did not exceed 1 meter (these data are specific for Brevard County areas and must be tested prior to its application to other oyster bed locations).

7) Upland discharge effects, where the results caused seagrass depletion or, the turbulence and settling caused bottom alterations.

8) Sandbars being formed and enlarged causing future land buildup or waterway constriction.

9) Other findings, appropriate to each study area (2, 5, 6, 7).

The following features could be detected from color infrared negative transparencies by inference. Here, inference means that, if A and B always appear together, and the presence of B is detectable and is detected on the aerials, one may assume that A is also present.

1) Rocky areas, and associated substratum specific seaweeds.

2) Freshwater runoff areas (drainage, creeks, springs) creating siltation by having water circulation which unsettles natural bottom covers.

3) Oyster beds not directly detected, but identified by their substratum configuration due to their substratum specific nature.

The foregoing features were depicted on area maps as they appeared. The following tabulated data represent the grassbeds and other features within each section.

TABLE 1

	SEA GRASSES		TYPES OF SEA GRASSES					SHELLFISH		CANALS	
	ACRES	Km^2	Rm	Dw	Sf	He	Tt	ACRES	Km^2	ACRES	Km^2
2	4448	18	x	x	x	x	-	-	-	257.3	1.04
5	6674	27	x	x	x	x	x	2509	10	-	-
6	8521	34.5	x	x	x	x		-		3491	14
7	25211	102	x	x	x	x		-		319.4	1.29

\- Not Assessed or Not Present

Km^2 Square Kilometers

R m Ruppia meritima

D w Diplanthera wrightii

S f Syringodium filiforme

H e Halophila engelmannii

T t Thalassia testudinium

RECOMMENDATIONS

For areas such as Brevard County, near infrared Kodak film, the Zeiss Camera, Filters Wratten 12 and 15, using the correct sun angle and lack of cloud cover, produced the best results in detection of estuarine underwater features. The initial sets of imagery adhering to the flight specifications proved best. The following observations and recommendations are made based on this study as suggestions in designing similar projects in the future.

The user should consider distortions caused by tilting and altitude changes of the aircraft, and calculate the degree for which such distortions can be tolerated in data use.

Long, straight flight patterns over water are very difficult to follow. Such water areas should be marked by anchored markers to aid the pilot in navigation. If economically feasible, a 60 per cent imagery side overlap will compensate for flight path deviations. The above 60 per cent is not necessary when flights take place under good weather conditions, (thereby minimize tilt altitude problems); or on short distances where a point of reference can be kept in sight all through the duration of flight. In long flight lines over water, however, where there is no anchored marker available, the 60 per cent side overlap is highly recommended.

If time or seasonal comparisons are planned, the same camera and processing techniques must be used.

In this project, underwater features did not seem to appear three dimensional with magnification or techniques used for land areas. Use of the steroscope did not produce steroscopic results.

In choosing a light table, sand blasted glass is preferred over frosted glass. Frosting has patterns which interfere with underwater configurations.

Wearing sun glasses helps lessen eye strain for long periods of time spent on the light table. Blocking off light table areas not used is essential in minimizing eye strain from excessive glare.

Without leaving a stain, plain soap and water will erase ink lines drawn on most milars used in mapping. In drawing very thin lines (Rapidograph 0 or 00) one must make certain that the lines are uniformly dark. Watered-down or thinned ink appearing gray, will disappear when copied.

The use of aerial imagery is the best available method found in mapping underwater features. For quantitative analysis of such parameters, this task would not have been possible without remote sensing data.

Imagery use reduced the need to do multiple sampling in several locations, by enabling us to apply data to similar areas revealed on the imagery. This saving of manpower, boat and equipment use and field time, makes the use of aerial imagery many times more cost effective than conducting field investigations alone.

The quantitative as well as the qualitative documentation of underwater features is a basic goal of environmental assessment in Brevard County. Once documented, these features need to be monitored periodically so that alterations to the system could be detected and evaluated. A continued program of remote sensing monitoring is a natural followup to this initial aerial imagery documentation effort, and is highly recommended by this investigator.